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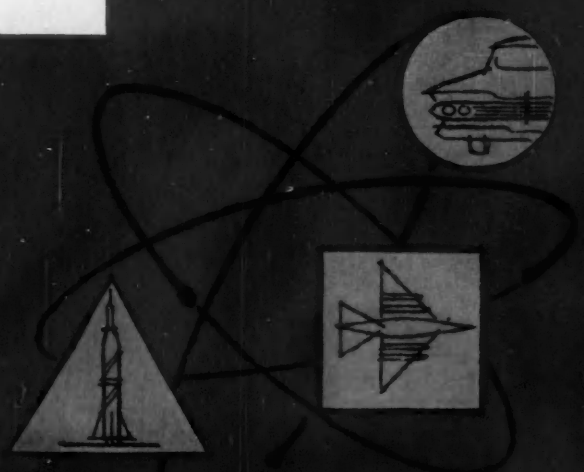

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Diesel locomotive repairs can cost less 36

Lower cost fuels containing residual fractions can now be used with diesel locomotives, without introducing greater wear, thanks to recent radioactive ring wear tests. With the improved operation, adopted as a result of the more than 200 test runs, the Southern Pacific Co. has saved an estimated $400,000 per year with its 167 unit residual fuel fleet. (Paper No. 362A) — **P. L. Pinotti, P. V. Garin, and D. R. Jones**

JetStar . . . new corporate airplane 38

Design started — 1956; certification — due late 1961. Features 10 place capability, nearly 500 mph speed, and 2250 nautical mi range. (Paper No. S310) — **E. B. Gibson**

How Peugeot studied noise reduction 44

To increase passenger comfort and reduce material and fatigue failure caused by strains induced by vibration, Peugeot undertook the study and isolation of car vibration and noise in its 404 model. (SP-185) — **Rene Bouquet**

Field experience with GMT-305 gas turbine 47

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How the transition was made from piston engine to jet within the existing overhaul plant. (Paper No. 373C) — **Lee Spruill and T. B. King**

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The vast increase in this century of man's knowledge of the physical world has pushed us to new levels of creative activity. Paradoxically, this new knowledge has led us to the humble conclusions that we really know much less about the physical universe than our grandfathers thought they knew a century ago. — **A. A. Kucher**

Stratified charge engine promises more Mpg 57

Renewed interest in stratified charge operation for spark-ignition engines has brough fresh research in this area. Here are the results of some recent work. (Papers Nos. 375B & 380F) — **Jean Baudry, Lewis D. Conta, Jose L. Bascunana and Pandeli Durbetaki**

Vacuum-processed alloys for tomorrow's cars 60

Three vacuum processes — now commercially available — are beginning to bid for the attention of automobile designers. Cost-performance elements are detailed here. — **A. M. Aksoy and P. Lillys**

Bow thrusters improve ship maneuverability 64

Bow thrusters — submerged propeller-driven devices located in the forward part of the hull of a vessel to provide bow control — are being installed more and more in new vessels and also in existing ships of all kinds. (Paper No. 376A) — **Howard H. Scott**

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Progress in automotive air conditioning 67

Designers are continuing to add to their knowledge of how to make automobile air conditioning more satisfactory — both in performance and cost. The major problems requiring study still pertain chiefly to conditions when engines are at idle or cars are operating at very low speeds. But much progress has been made in the last 36 months on engine cooling, V-belt constructions, compressors, design of clutches used to pick up compressors, and on thermostatic expansion valves — which are common to all automobile air conditioning systems. (SP-185)

How to select right vehicle for the job 70

Little divergence of opinion appears among fleet operators about how to select the right vehicle for the job. But each type of service brings emphasis on different factors as of major or minor importance. (TPS-2)

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Power assist needed to offset heavier front end axle loadings and wider steering angles. (Paper No. 368A) — **T. I. Monroe**

Gas turbine vibration can be stopped 75

In a high speed rotating system, such as a gas turbine shaft, critical speeds can be placed outside the operating range by using flexible bearing supports. Forces transmitted to the stationary structure can be reduced at the same time. (Paper No. 382B) — **Glenn Hamburg and Jon Parkinson**

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For years, United Parcel Service has specified radiator shutters on all their equipment . . . to have June in January under the hood. Recent tests show the benefits of such a cooling system. (SP-194) — **Peter P. Kazlauskas, D. R. Ferris, and Walter R. Herfurth**

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Road safety research admits to two methods of attack. In one, the "survey" technique, we take the world as we find it, and describe what we find as best we can. The second method includes experimental techniques, where desired situations can be created. (Paper No. 366B) — **John Versace**

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Maybach diesels feature tunnel crankcase 90

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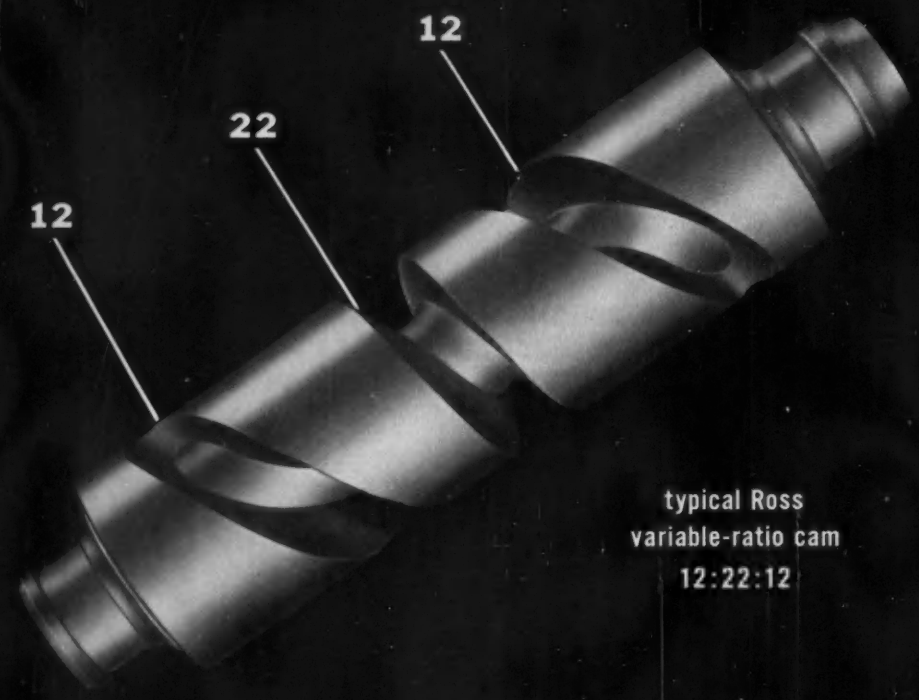

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AEROSPACECRAFT

Thermal Radiation Considerations for Advanced Flight Vehicles, H. J. SIEGEL, D. L. KUMMER. Paper No. 280E. Utilization of radiative systems for control of heat transfer on advanced flight vehicles and means of achieving high and low emissivity surfaces on present and future vehicles; it is pointed out that temperature of space vehicles is dependent upon thermal radiation characteristics of exterior surface; applicable materials, methods of measuring their thermal radiation properties, and determination of solar absorptivity and emissivity.

Lift-Thrust Turbofan Engines for VTOL and STOL Aircraft, P. H. J. YOUNG. Paper No. 337A. Design and development of powerplant which is combination of conventional front mounted turbofan engine with system of rapidly rotatable exhaust nozzles; development of Bristol Siddeley BS 53, basic considerations, and thermodynamic parameters which fix engine design are turbine entry temperature at take-off, h-p compressor pressure ratio, bypass and fan pressure ratio; application of engine to single-engined V/STOL fighting aircraft for subsonic and supersonic roles.

Nuclear Ramjet Control System Design, Performance, Environmental Requirements, M. M. WEINTRAUB. Paper No. 338D. Principles of ramjet propulsion and comparison of ramjets, turbojets, and rockets; use of nuclear reactor as heat source and its effects; speed and altitude limitations and use of rods as neutron absorption controls for nuclear ramjet; analysis of performance requirements of control rod mechanisms; environmental requirements for control components, divided into sensors, computing devices, and actuators.

Commercial Supersonic Transport — Some Operational Considerations, J. G. BORGER, L. H. ALLEN, N. D. FOLLING, W. F. HIBBS. Paper No. 341A. Analysis made by Pan American World Airways with regard to possible configuration, size, speed, range and fuels of future SST (Supersonic Transport); flight and performance; to investigate economisc, IBM 705 computor was used to simulate operation of Mach 2 aircraft over portion of present route; it is shown that SST did not have same revenue producing capabilities which were 8% less than jet; recommondations made relating to future design.

Trans-Canada's Experience with Rolls Royce "Conway" Turbine Engine, J. T. DYMENT, J. J. EDEN. Paper No. 345C. Review of experience covering 1-yr DC-8 operation and over 42,000 engine hours accumulated by Trans-Canada Airlines; tabulation of average and guaranteed performance of RCo12 Conway engine; accessibility, operational procedures and problems; in-flight shutdowns, and unscheduled removals, overhaul life development and preventative failure analysis.

Pilot's View of Certification Testing and Development of Operational Procedures for Jet Transports, W. M. MAGRUDER. Paper No. 348D. Paper offers testing and operational techniques designed to simplify certification and operation of such aircraft as present United States jet powered fleet; certification requirements for takeoff, and method for determining minimum lift-off speed; selection of normal lift-off speed and takeoff trim; pilot aid devices for takeoff; takeoff noise abatement procedures; thrust setting procedures after takeoff, landing and approach techniques.

Crylocycle: New Concept in Room-Temperature Integrated Thermal Control and Power-Generation System, J. R. MAY, D. H. SILVERN. Paper No. 350D. Integrated cooling and power generation arrangement by Sundstrand Aviation combining current isothermal expansion system with expansion en-

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gines and heat exchanger design; basically, it is open Rankine cycle with reheat between stages; combustion process is carried out in catalytic reaction chamber; expander and other major components of engine system; operational characteristics and advantages for space applications.

Radiation Fuel Gage Applications to Transport Aircraft, C. F. BURNAP. Paper No. 356C. Gage, developed by North American Aviation, consists of radioisotope sources, detector with housing, summing unit in aircraft with several tanks, and instrument panel indicator; sources, placed around tank, are Cobalt 60 or Cesium 137; major components of system and their functions; fuel impurities, including moisture, have no effect on its operation, and payloads may be increased if desired as result of increased accuracy and reliability in fuel reading.

Special Aspects of Structural Design for Safety of Light Aircraft, K. H. BERGEY. Paper No. 365A. Airworthiness deals with ability of airframe to withstand loads, static and dynamic, imposed by flight; crashworthiness deals with protection of pilot and passengers in accident; 10 recommendations made by Crash Injury Research unit of Cornell Medical College; designer should consider that accidents in which cabin is not collapsed or disintegrated should be survivable, and that head injuries account for 80% of deaths; structural fatigue factors.

Trends in Light Aircraft Structural Design, J. H. GERTEIS, J. C. DUSSALT. Paper No. 365B. Review of progress made in past 40 yr and analysis of trends observed relating to strength requirements, new materials and construction methods; examples of current trends.

Beech Turboprop Travel Air Test Bed — Progress Report, M. J. GORDON. Paper No. 365C. Progress report on program which is joint effort by Beech, SFERMA, Turbomeca, and Ratier-Figeac to develop small twin engine aircraft with turbines of high performance characteristics; development of fixed shaft Astazou Turboprop engine, manufactured by Turbomeca of Bordes, France; it has one stage of axial compression and second stage centrifugal compressor, centrifugal fuel injection system, 3-stage axial turbine and is rated at 43,000 rpm for take off; flight characteristics.

Two-and-a-half Years of International Operation with the Boeing 707 by R. W. BLAKE. Paper No. S309. Covers 133,997 flying hours experience with the Boeing 707. Experiences with environment, airport runways, fuel reserve usage, noise, powerplants instrumentation, and flight crews are discussed.

FUELS & LUBRICANTS

Jet Fuel Anti-Icing Additives — New Concept in Safety of Flight, W. C. FRENCH, E. A. MALICK. Paper No. 356B. Development of additive known as PF A 55MB, by Phillips Petroleum Co., as result of several years' laboratory and flight testing by U. S. Air Force, and Boeing-Wichita; performance criteria, types of chemical additives tested, and results of laboratory testing; flight test program, and laboratory compatibility test methods developed.

Navy Gas Turbine Fuel Studies by J. R. BELT. Paper No. S305. Covers effects of fuel properties on gas turbine performance, the effects of salt water contamination of the fuel, how engine load affects deposition rate, deposit data on a large number of fuels.

GROUND VEHICLES

Wolfwagons and What Makes Them Tick, L. J. WOLF. Paper No. 358A. Details of component controls of Wolfwagon, built by St. Louis Car Co.; engine package is complete unit, carrying engine and transmission with radiator and accessories in its own subframe; wide selection of both diesel and gasoline engines, and all standard tire and wheel sizes and types are offered; Wolfwagons are set up to run singly,

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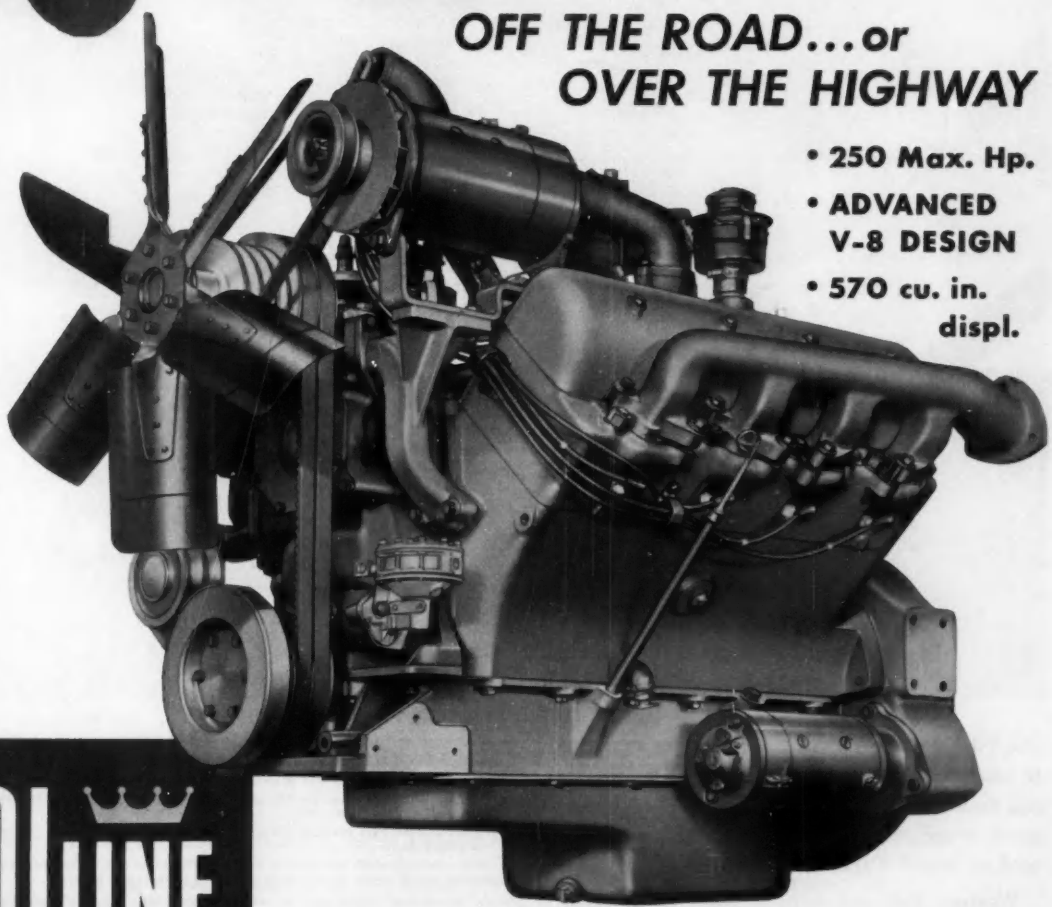

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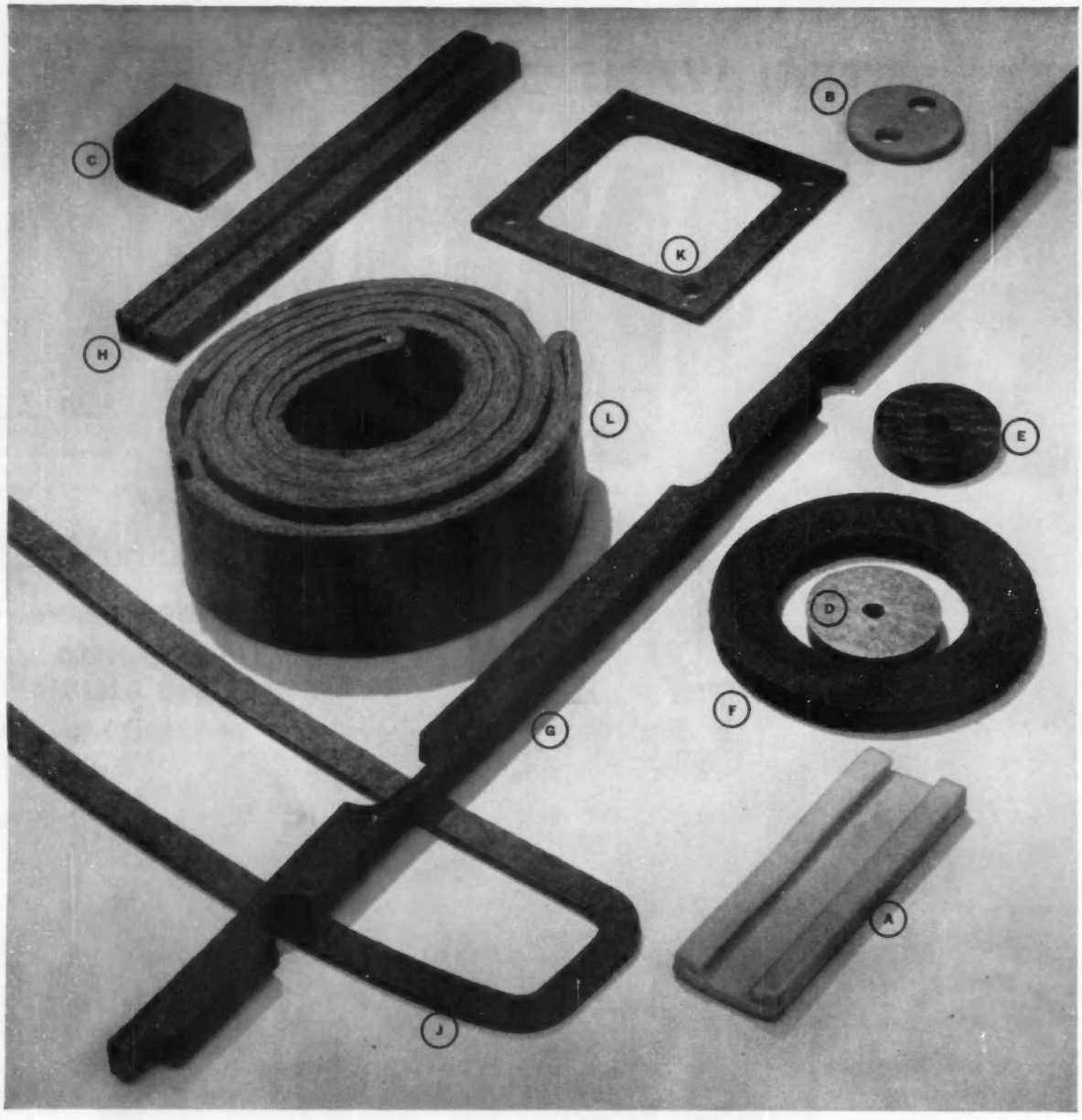

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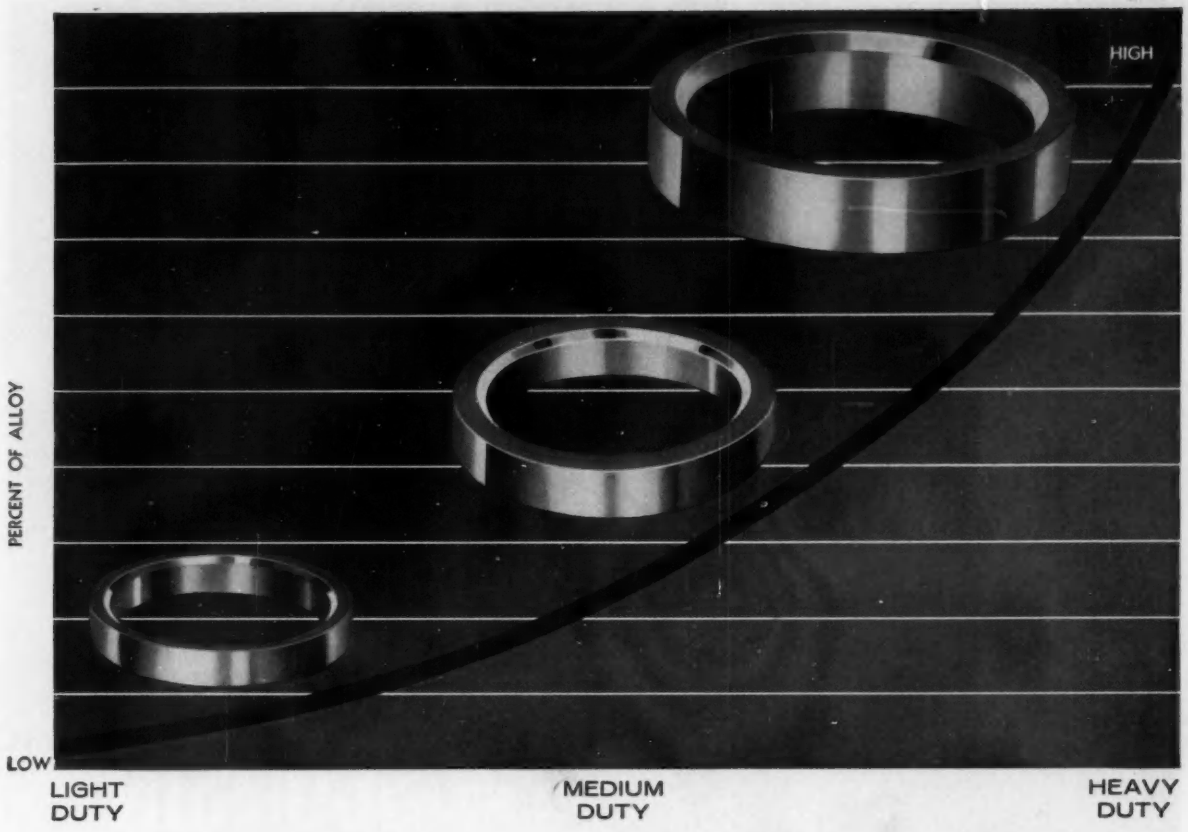

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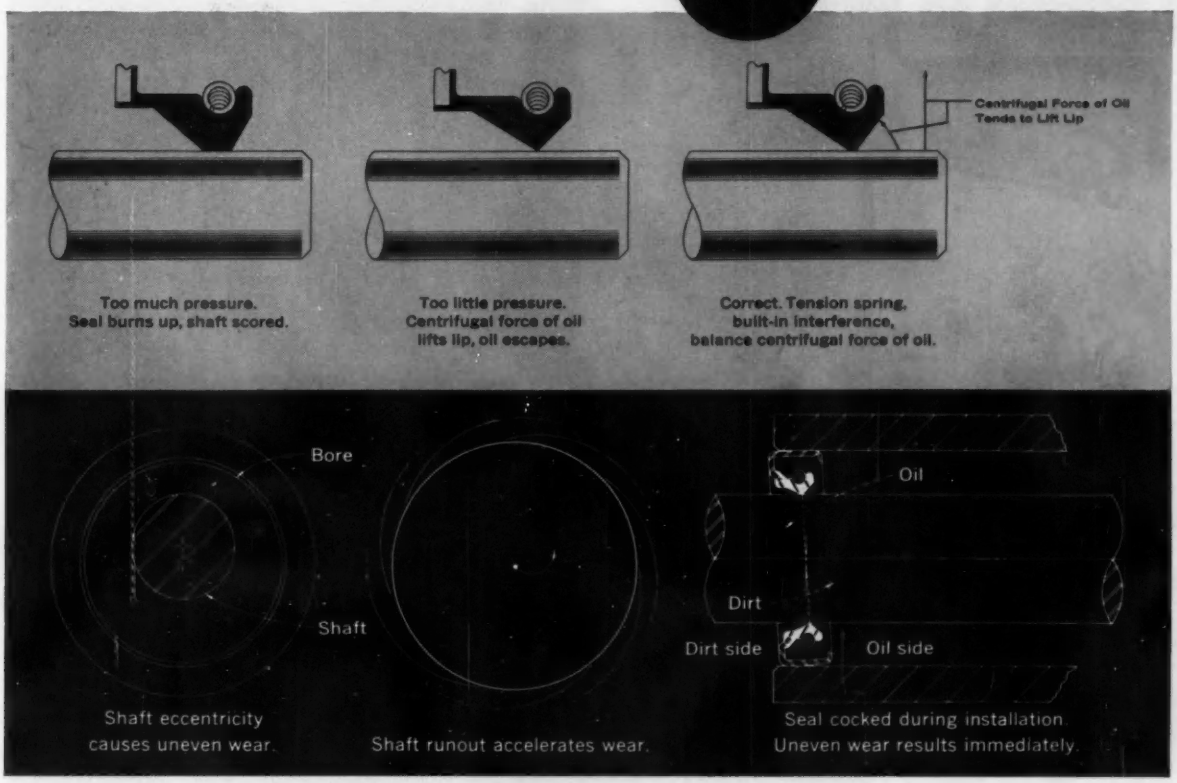
Lip pressure...too much or too little, and you've a leaker for sure!


Centrifugal Force of Oil Tends to Lift Lip
Too much pressure. Seal burns up, shaft scored.
Too little pressure. Centrifugal force of oil lifts lip, oil escapes.
Correct. Tension spring, built-in interference, balance centrifugal force of oil.
Bore
Shaft
Shaft eccentricity causes uneven wear.
Shaft runout accelerates wear.
Oil
Dirt
Dirt side
Oil side
Seal cocked during installation. Uneven wear results immediately.

Ideal sealing conditions are (1) shaft in bore center, (2) no runout, (3) seal not cocked, (4) seal concentric, (5) bore round and smooth, (6) shaft round and properly finished, (7) seal proper size.

Meeting these conditions is complicated, frequently requires special seal design or the specialized knowledge of National Seal engineers.

Sealing problems should be anticipated and answered on the board, not in production. Why not call your National Seal engineer now about your current project. He's in the Yellow Pages, under Oil Seals or O-Rings.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, Calif.

GN

Pedrick

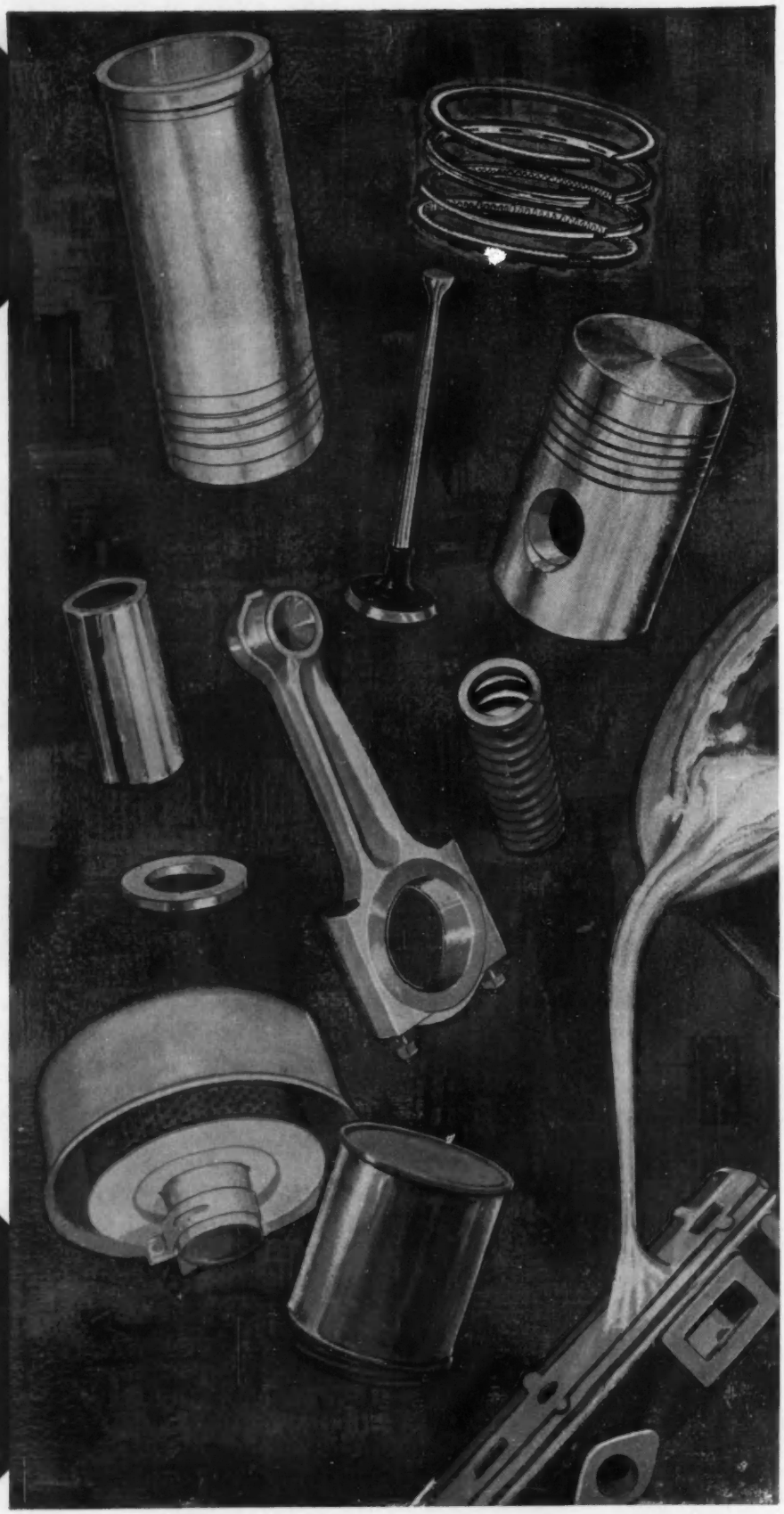
SUPERIOR

WHITE
MACHINE WORKS

BURD
GRAY FLOX

GE

GN



Nation's largest manufacturer of heavy-duty and specialized engine parts—

NEW GOULD-NATIONAL ENGINE PARTS DIVISION

In creating its new Engine Parts Division, Gould-National combined under one corporate roof the brands, products, services and facilities of these wholly-owned subsidiaries:

Wilkening Manufacturing Co., Philadelphia, manufacturers of Pedrick® piston rings, components and castings.

White Machine Works, Eau Claire, Wisconsin, manufacturers of Superior-Arrowhead cylinder sleeves, sleeve assemblies, pistons, piston pins, Burd pistons, rings, valves and valve train parts, foreign car engine parts and filters.

Gillett & Eaton, Lake City, Minnesota, piston and casting specialists of cast iron, aluminum alloy, Vanasil® aluminum alloy pistons and specialized engine parts.

Arrow Head Steel Products, Howell, Michigan, manufacturers of aluminum pistons, connecting rods and other castings.

Now, Gould-National, the nation's largest producer of automotive replacement batteries, is also the nation's largest basic manufacturer of heavy-duty and specialized engine parts. The Division is the largest one stop source for the most complete line of engine parts available from one manufacturer. It is the only engine parts manufacturer with both iron and aluminum casting and machining facilities.

With this one stop source of supply, customer ordering is greatly simplified. So is customer control over the order. Streamlined order handling procedures assure the fastest possible response to customer requirements.

All standard parts will be available through an established nation-wide network of warehouses and distributors. This efficient decentralized distribution of parts will mean faster customer service.

By utilizing the efforts of one combined sales force, the customer will benefit from greater sales-service efficiency, more concentrated field coverage.

Product improvement will result from the formation of a special team in the Gould-National Engineering and Research staff. It is the Gould-National way of assuring continuing top quality and improved product performance.

New engineering developments, manufacturing and production techniques from all areas within the Division will benefit all customers, no matter what the product may be.

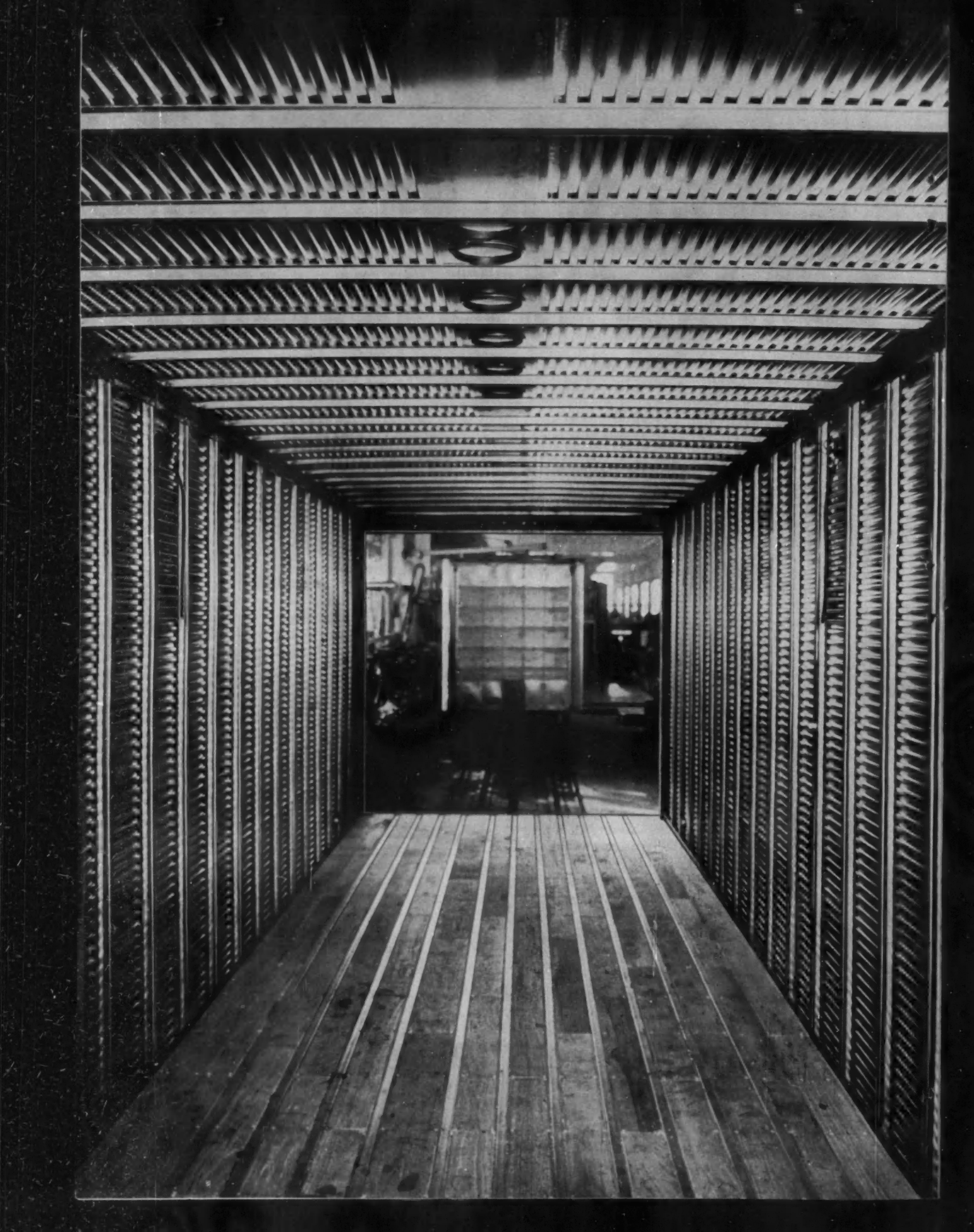
This is the Gould-National Engine Parts Division—the nation's newest parts manufacturing group with over two centuries of combined experience.

Need heavy-duty engine parts? Foreign car engine parts? Parts for such specialized applications as air and refrigeration compressors? Need complete and modern facilities for aluminum and iron castings? If your specifications call for the best of these, if you need them fast and need them right . . . turn to . . .

Superior-Arrowhead and Burd are trademarks of Gould-National Batteries, Inc.

GN

ENGINE PARTS DIVISION
GOULD-NATIONAL BATTERIES, INC.
St. Paul 1, Minnesota



MECHANICAL PROPERTIES*

	YOLOY E HSX	YOLOY E HS	YOLOY E ACR
Carbon, max. %	.18	.18	.10
Manganese, max. %	1.00	1.00	.60
Phosphorus, max. %	.09	.10	.05
Sulphur, max. %	.05	.05	.05
Silicon, max. %	.30	.30	—
Copper %	.20/.50	.20/.50	.25/.50
Nickel %	.40/1.00	.40/1.00	.60 max.
Chromium %	.20/.60	.20/.60	.35 max.
Yield point, psi	45,000 min.	50,000 min.	45,000 max.
Tensile Strength, psi	80,000 max.	70,000 min.	60,000 max.
Elongation in 2", %	25.0 av.	.22 min.	30.0 av.

*Mechanical properties for Yoloy E steels up to ½" in thickness.

ADDITIONAL TYPICAL MECHANICAL PROPERTIES

Ultimate compressive strength: equal to tensile strength.
Ultimate shearing strength: equal to ¾ of tensile strength.
Modulus of elasticity, psi_____29,000,000

ASTM STANDARD COLD BEND TESTS

½" thick and under shall bend 180° around pin whose diameter is equal to one (1) times thickness of sheet, plate or bar.
Over ½" thick shall bend 180° around pin whose diameter is equal to two (2) times thickness of the bar or plate.

FABRICATING PRACTICE FOR COLD FORMING

THICKNESS OF PRODUCT	YOLOY E HS SUGGESTED MINIMUM INSIDE RADII	YOLOY E HSX SUGGESTED MINIMUM INSIDE RADII
up to 1/16" inclusive	1 x thickness	1 x thickness
Over 1/16" to 1/4" inclusive	2 x thickness	1½ x thickness
Over 1/4" to 1/2" inclusive	3 x thickness	2½ x thickness

YOLOY

high strength steel lasts longer, weighs less, does more for you per mile, per load

Youngstown's Yoloy E steel is brawny, durable, with up to 40% more strength than ordinary steels. It lasts longer, is easier to form, weld, use. It has up to 6 times more corrosion resistance. Even paint adheres better.

Cars, trucks and trailer bodies of rugged low-cost Yoloy E are strongest per pound, most economical per mile on roads, today. The nation's big trucking firms know this and make it pay off for them in performance.

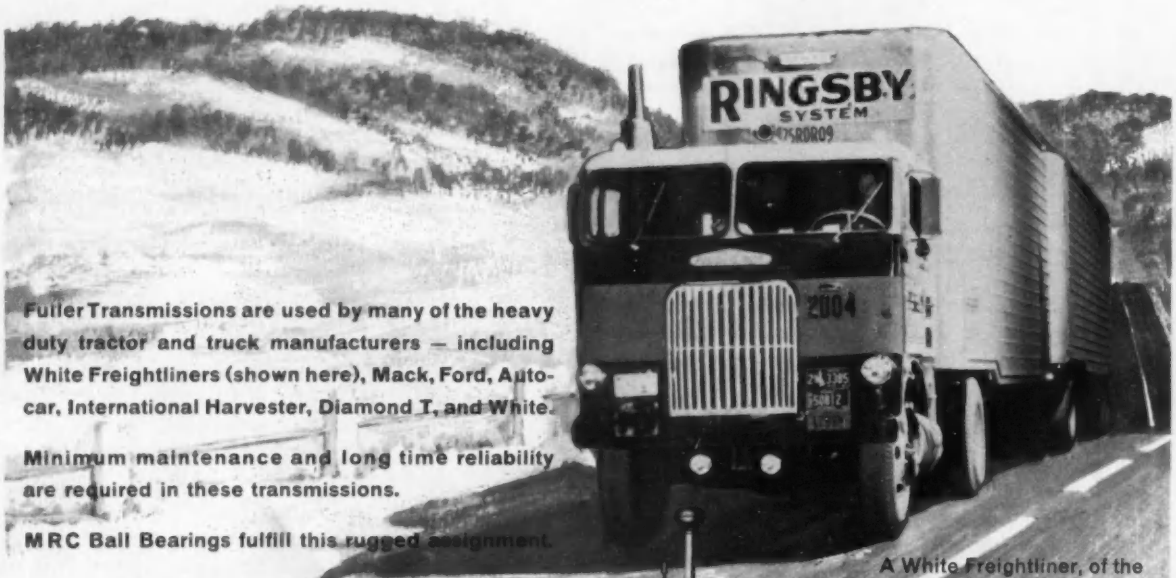
Get the proved longer service, easier fabrication and assembly, the economy of remarkable Yoloy E steel. Choose from 3 different types, each made to fit your special requirements: Yoloy E HSX, Yoloy E HS, and Yoloy E ACR.

Yoloy steels are a product of Youngstown integrated steel-making where quality and delivery are rigidly controlled from mine to open hearth to high-tensile cut plate and coiled sheet. For your high strength steel needs, choose Yoloy, one of over 800 quality steels from Youngstown.

Youngstown – growing force in steel

For more information about Yoloy Steel, write: Department 3-B.
The Youngstown Sheet & Tube Company, Youngstown, Ohio

MARLIN-ROCKWELL RELIABILITY COUNTS in FULLER TRANSMISSIONS *that keep 'em rolling!*

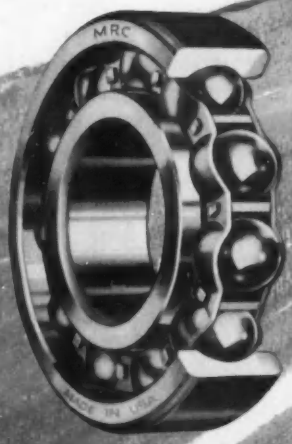


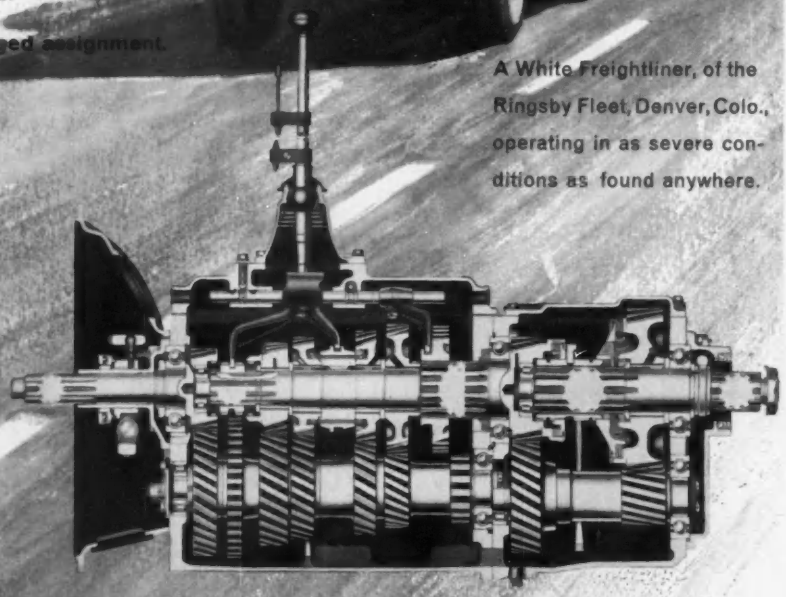
Fuller Transmissions are used by many of the heavy duty tractor and truck manufacturers — including White Freightliners (shown here), Mack, Ford, Autocar, International Harvester, Diamond T, and White.

Minimum maintenance and long time reliability are required in these transmissions.

MRC Ball Bearings fulfill this rugged assignment.

A White Freightliner, of the Ringsby Fleet, Denver, Colo., operating in as severe conditions as found anywhere.





MRC Ball Bearings — first made for the automotive industry before the turn of the century — are still the utmost in reliability.

R-96 FULLER ROAD RANGER TRANSMISSION

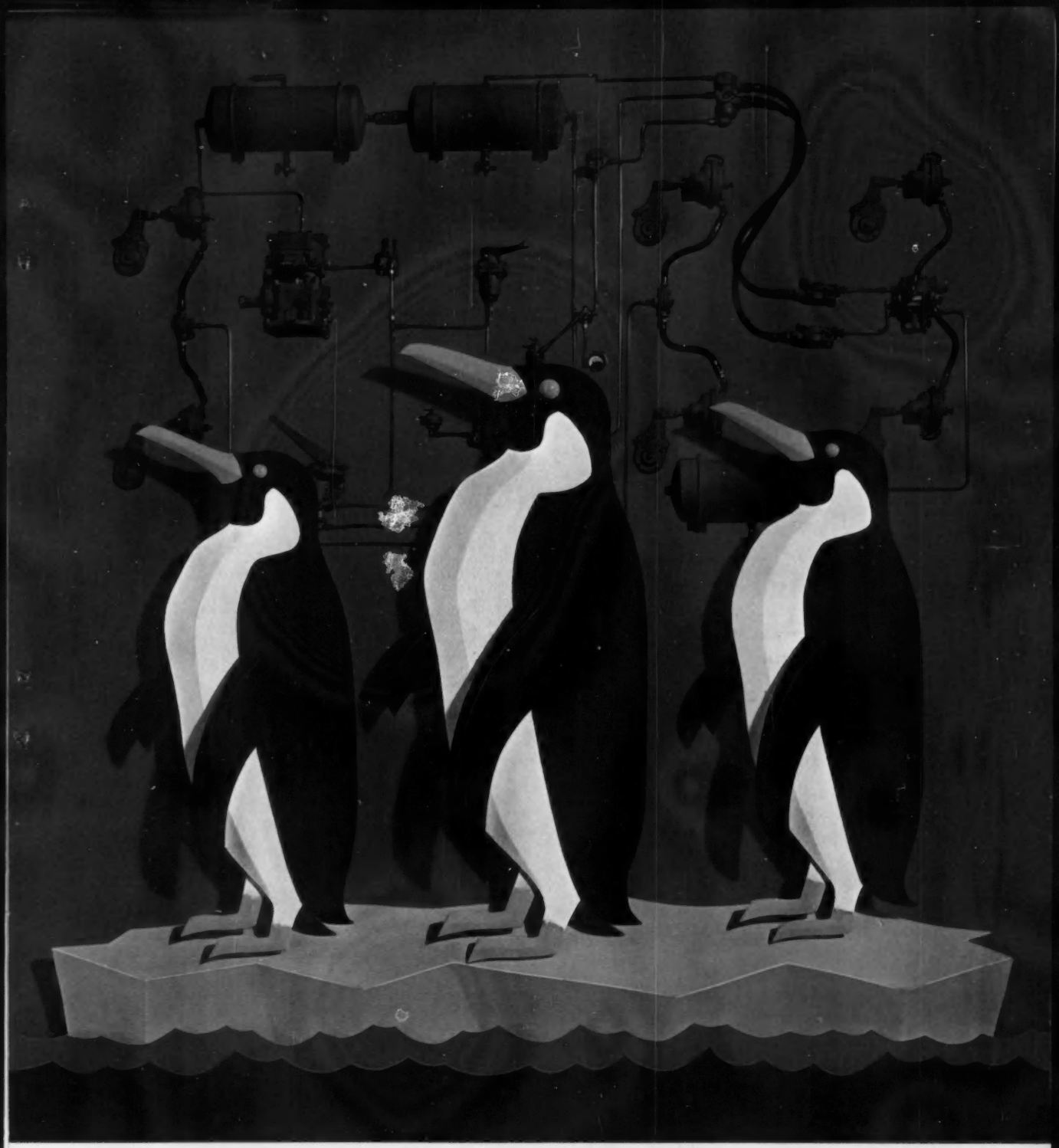
BACKED BY 63 YEARS EXPERIENCE

Consult OUR Engineering Dept. on YOUR Bearing Problems

MRC BALL AND ROLLER bearings

MARLIN-ROCKWELL CORPORATION

Executive Offices: **Jamestown, N. Y.**



AIR BRAKES MAY ALSO LOOK ALIKE . . . BUT. It's hard to tell one penguin from another—and it really doesn't matter about penguins anyway. It's also difficult to tell one air brake system from another by looking at them—but here the similarity ends. For just like most other products, air brake systems vary—in quality, in performance, in reliability, and in the reputation of the company that makes them. By every one of these measurements, Bendix-Westinghouse air brake systems consistently have led the industry for 38 years. That's why you can buy with complete confidence when you specify Bendix-Westinghouse Air Brakes—the product and name you can trust.

SPECIFY COMPLETE AIR BRAKE SYSTEMS BY *Bendix-Westinghouse*

BENDIX-WESTINGHOUSE AIR BRAKES®

ONLY BENDIX-WESTINGHOUSE OFFERS YOU SUCH STRONG FIELD SUPPORT

- More than 500 distributors and thousands of vehicle dealers
- 70 factory field representatives with 896 years' experience in the business
- 4 strategically located air brake plants

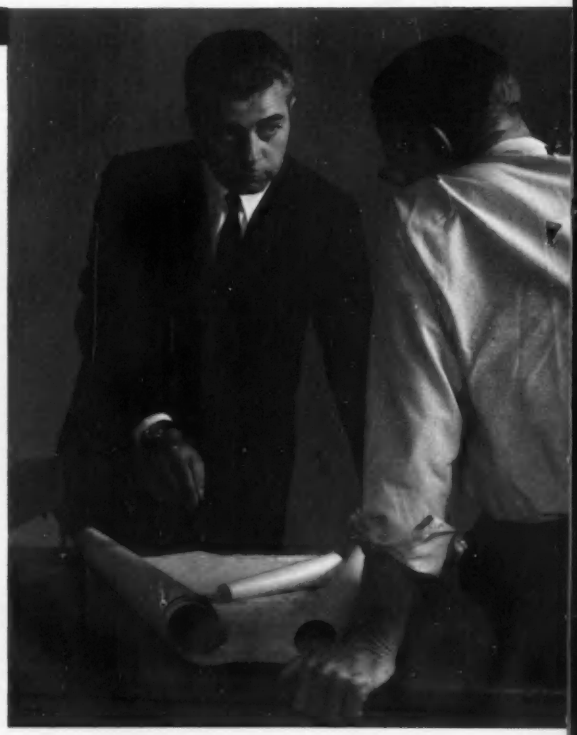
No matter where you operate your trucks, trailers, buses, or off-the-road equipment, Bendix-Westinghouse quality products and service are nearby, assuring economy and dependability unmatched in the air brake industry.

Your closest Bendix-Westinghouse distributor has over 500 counterparts throughout the United States. All of them are air brake experts, and 40 of them have been with us for more than 25 years.

Bendix-Westinghouse service parts and components also are available from thousands of truck and trailer dealers whose vehicles are equipped with our air brakes. Four U.S. plants whose facilities are devoted entirely to air brake equipment assure a smooth, steady flow of products to your serviceman. The 70 service-sales representatives who staff our eight regional offices have years of experience and training to offer you on any braking problem.

Add up these benefits, and it's easy to see why fleet operators, who know air brakes best, always look for the sign—"Bendix-Westinghouse." It's displayed from coast to coast.

Our distributors can provide the answers to all your air brake needs . . . whether it's advice, genuine replacement parts, Repair Exchange Service, brand new units, air brake conversion kits, or accessory kits.



Bendix-Westinghouse service-sales representatives work directly with fleet operators, vehicle manufacturers, distributors, and dealers in serving the trucking industry's needs.

Bendix-Westinghouse

AUTOMOTIVE AIR BRAKE COMPANY

BENDIX-WESTINGHOUSE SINCE 1923 PACEMAKER IN TRANSPORT SAFETY

General offices and factory—Elyria, Ohio. Branches—Berkeley, Calif.; Oklahoma City, Okla.; Salisbury, N. C.

stainless steel adds sales appeal.

the car designed with stainless steel looks better when you buy it and is worth more when you sell it.

McLOUTH STAINLESS STEEL

McLouth Steel Corporation · Detroit 17, Michigan

Look for the **STEELMARK** on the products you buy

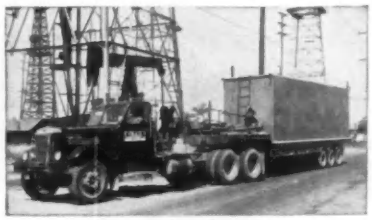
THE
finest

WAUKESHA TRANSPORT ENGINES

up to 400 HP

- *Easy Starting*
- *Reliability*
- *Simplicity*
- *Smoothness*
- *Economy*

Heavy materials delivery



Heavy-duty hauling

Fire fighting equipment

Inter-city tank trucks

Steep-grade transport

Snow plows and trucks

Transcontinental trailer hauling

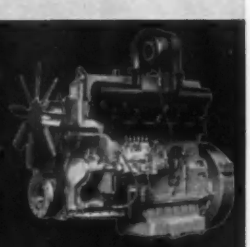
Power for extra-heavy loads

Off-the-highway service

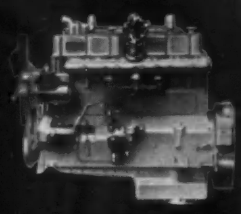
Milk run . . . or *any* run

508

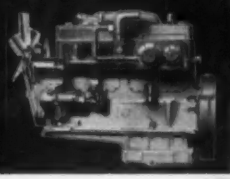
WAUKESHA WAKDBS TURBOCHARGED DIESEL . . .
6¼x6½" bore and stroke, 1197 cu. in. displ., up to 400 hp. at 1800 rpm.



WAUKESHA 145-GZ HIGH OUTPUT GASOLINE ENGINE
5½x6" bore and stroke, 877 cu. in. displ., up to 320 hp. at 2800 rpm.

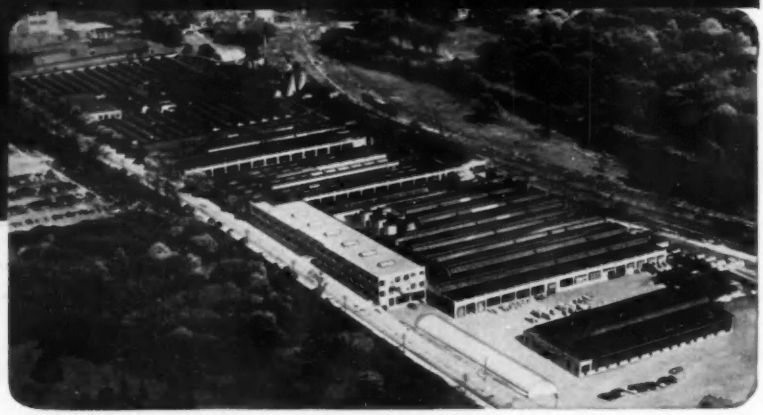


WAUKESHA WAKC BUTANE-PROPANE ENGINE
6¼x6½" bore and stroke, 1197 cu. in. displ., up to 315 hp. at 1800 rpm.



DIESEL
GASOLINE
BUTANE
ENGINES

EXCEPTIONAL PLANT FACILITIES
25 ACRES OF MANUFACTURING SPACE



Write for descriptive literature

WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN
New York • Tulsa • Huntington Park, Calif.
Factories: Waukesha, Wisconsin, and Clinton, Iowa

ORONITE®

presents
the first
ashless
detergent
additive

This new additive offers compounders and oil marketers the opportunity to provide their customers better motor oils. It's being offered alone or in formulations containing zinc dithiophosphate known as Oronite 1200 Series lubricating oil additives.

Developed specifically for low temperature (stop-and-go) gasoline engine service conditions, these new additives also provide good high temperature gasoline and diesel performance. The low ash content offers better control of engine combustion phenomena with resultant lowering of octane requirement increase and reduced surface ignition tendencies.

Both lab and field tests have demonstrated significent advantages from oils compounded with Oronite 1200 Series additives. Why not get the complete story? See how the oil products you produce or market can be made more saleable.

Contact the Oronite office nearest you.

CALIFORNIA CHEMICAL COMPANY
ORONITE DIVISION

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FOREIGN AFFILIATE • California Chemical International, Inc., San Francisco, Geneva, Panama, Sao Paulo

BENDIX BROADENS ITS DIESEL FUEL INJECTION CAPABILITIES WITH ADDITION OF SIMMS LINE

Through a recent agreement with Simms Motor Units, Ltd. of London, England, Bendix will market and manufacture Simms fuel injection equipment for diesel engines in the United States. Thus, diesel engine manufacturers and users will benefit through an extremely wide range of equipment for their fuel injection needs.

Equipment manufactured by Scintilla Division of Bendix today is serving the fuel injection needs of leading U. S. diesel builders, particularly in the high-horsepower class. Now, with the addition of the Simms equipment, Bendix can offer multi-cylinder pump units adaptable to small- and medium-sized engines. Simms equips many makes of British diesels, as well as Ford diesel-powered farm tractors built in this country.

The nation-wide organization of Bendix® fuel injection equipment distributors and service dealers will perform equivalent functions on the Simms units, with prompt deliveries and efficient service. For details, write:

Scintilla Division
Sidney, New York

THE Bendix CORPORATION

Export Sales & Service: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

safety first

This EHRENREICH SELF-LUBRICATING ball joint is used for steering assemblies of the highest standard by the best known motor car manufacturers on the European continent. It has stood the test for years in motor cars all over the world under the most difficult conditions.

EHRENREICH

A. EHRENREICH & CIE. Düsseldorf-Ok. Germany

40. INTERNATIONALE AUTOMOBIL-AUSSTELLUNG FRANKFURT (MAIN) vom 21. 9. – 1. 10. 1961

48e SALON DE L'AUTOMOBILE PARIS, 5–15 OCTOBRE 1961

43° Salone Internazionale dell'Automobile Torino 28. 10. – 8. 11. 1961

Strong, Modern, Dependable

Stainless steel hub caps produced by Eaton Manufacturing Company, Cleveland, Ohio, for the Ford Motor Company.

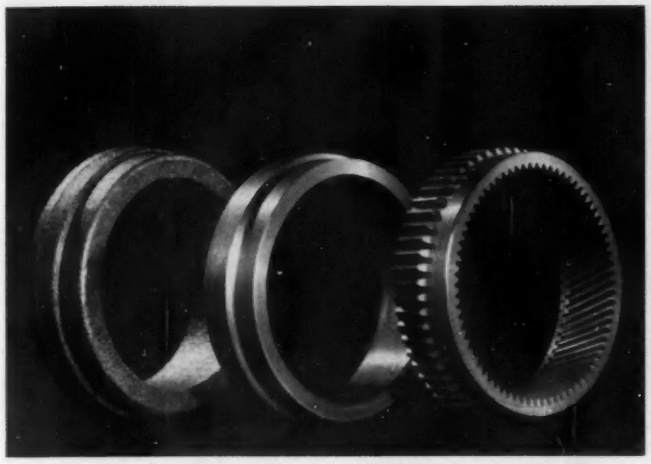
WHY FORD HUB CAPS ARE STAINLESS STEEL

When contracts were placed for the production of hub caps for 1961 Ford Passenger cars, there were two winners: The Eaton Manufacturing Company and Republic ENDURO Stainless Steel.

The use of stainless resulted in *better hub caps*—stronger, more resilient, with maximum resistance to chemical attack and abrasion. In producing these hub caps, Eaton uses Type 430 anti-roping stainless steel. The material is blanked, stamped, stamped again, roll formed, letter painted, cleaned, and buffed. A major portion of the stainless is supplied by Republic.

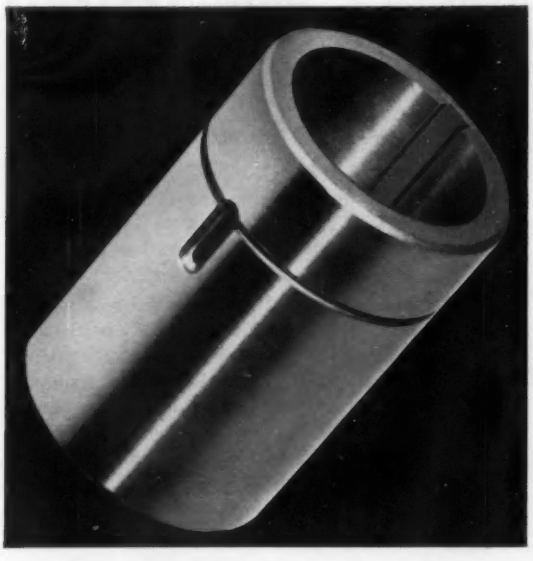
CONSISTENT QUALITY: Republic, the nation's largest producer of stainless and alloy steels, offers consistent quality in 45 standard types of stainless steel, and in anti-roping . . . bright annealed . . . precipitation hardenable . . . and vacuum melted stainless steels. Field metallurgists help you select and apply the most economical material capable of meeting your requirements.

For information, quotes, or metallurgical assistance, call your nearest Republic sales office. Or, mail the coupon at right.



CONSISTENT QUALITY CUTS REJECTS: Republic Type 4047 Hot Rolled Alloy Steel is used in planetary ring gears produced by the Warner Gear Division of Borg Warner Corporation. The alloy is forged, rough machined, broached, hobbed, and heat treated. Production records prove that the uniformity of Republic Alloy Steel has reduced reject rate and scrap loss. Uniform response to heat treatment assures maximum resistance to shock, strain, and wear. Mail coupon below for data on alloy steel.

NEWEST METHODS SAVE YOU MONEY: Republic Formed Parts "Specials"—made to *your* specifications—can be cold formed, hot formed, extruded, upset, or produced by combinations of these processes. Complete machining, heat treating, and surface finishing equipment available. Republic has produced over 12,000 "Specials" for customers. This one-source operation, with built-in economies and quality controls, can save you time, money, and problems. Call your Republic representative or mail the coupon.



CONCENTRIC TUBE CUTS MACHINING: Eaton Manufacturing Company is using low-cost Republic ELECTRUNITE Mechanical Tubing as the internal drive shaft in their power steering pumps. Tube's concentricity minimizes machining requirements on the ID and OD of this bushing. Use in this hydraulic application also underscores the structural soundness of ELECTRUNITE Mechanical Tubing. Here is premium quality at low cost. Available in carbon or stainless steel. Talk to your Republic salesman or mail the coupon.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

REPUBLIC STEEL CORPORATION
DEPT. SA-2435
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

☐ ENDURO® Stainless Steel ☐ Formed Part "Specials"
☐ Alloy Steel ☐ ELECTRUNITE® Mechanical Tubing

Name_____ Title_____

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Address_____

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For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVENE DIVISION, 1243 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

C/R

For Sake of Argument

Excerpts from a Foreword . . .

THE OLD American idea that individuals spark successful action still holds good in our modern integrated economy. But today each individual must find ways to make group effort a tool through which many individuals may achieve together . . . and through which each individual can make his personal contribution.

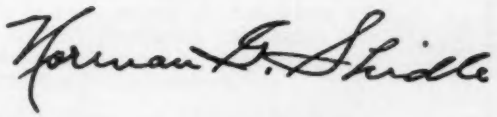
Most action is taken in today's United States — for good or for ill — by groups. This makes the need for the individual greater than ever — but magnifies the complexity of his problems.

Group results come only from synthesis of individual actions. Unless the individual *acts* within the group, the group remains a spineless amoeba.

Many of the essays included in "Instincts in Action"* (by Norman G. Shidle) aim to help individuals to exercise their individualities in achieving the most important freedom left in modern industry; the freedom to cooperate.

Most of the essays are commentaries on *how* people act — especially in business; and *why* they act the way they do.

Best clue to the author's frame of mind in writing is that all of the essays appeared under the heading, "For the Sake of Argument" when they were originally printed in SAE Journal.



* This new volume includes more than 140 "For Sake of Argument" pieces selected from those printed between 1946 and 1961. . . . Published by SAE, it is now available for distribution and may be ordered by circling SP-222 on p. 6.

Morse quality timing chains: best under the sun for more than fifty-six years

There are good reasons why Morse timing chains are original equipment in over 76% of all American cars. For more than 56 years they have provided perfect valve timing—like the timing of a fine watch, and every bit as quiet. Morse quality control is of the highest order, from steel purchased in special mill runs, to laboratory hardness tests, to demagnetization. As a finishing touch timing chains are even vacuum-cleaned to remove foreign particles which might affect long life. What better reasons could there be for anyone to specify Morse? For further information, write: Morse Chain Company, Dept. 12-91, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

MORSE

A BORG·WARNER INDUSTRY

B·W

chips

from SAE meetings, members, and committees

VACUUM-MELTED STEEL ALLOYS are beginning to find occasional applications in automobiles . . . as in the recent case of a plunger barrel made from air-melted Airdi 150 for a diesel fuel pump. The pump performed unsatisfactorily. Pitting out of nonmetallic inclusions around the small orifices in the plunger kept destroying control of fuel metering. So, vacuum-arc-welded Airdi 150 was substituted for the air-melted material. Result: the pump has performed satisfactorily since the substitution. (See p. 60 for more about new possibilities from vacuum processed alloy steels.)

THERE ARE MORE THAN three times as many 2-stroke spark-ignition engines in use today than there were at the end of World War II. As a result, the annual demand for oils for these engines — 28 million gallons in 1960 — is now about equal to the oil used by all diesel locomotives in the United States in a year.

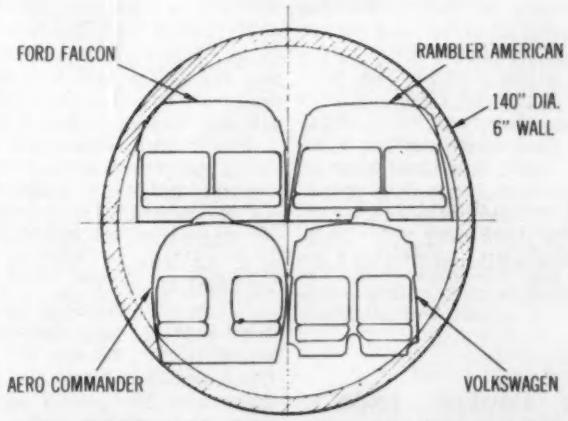
FEWER NEW PRODUCT PAPERS at SAE ground vehicle sessions are being predicted informally by some members. Trend of car companies toward a policy of "limited" model changes on compact cars (in contrast to the traditional yearly model change for standard models) is one of the reasons mentioned. . . . But, in the same breath, it is said that specific engineering changes may be on the increase. Progress in the art of casting accurate, thin, gray-iron castings, for example, is intensifying designers' attention on materials selection for parts lately swung to aluminum. Field experience being accumulated on aluminum engines might suggest design modifications . . . and the trend toward higher-mileage and longer-time warranties is already having important design influences. (Along with chances of landing on the moon, some say a 100,000-mile warranty may yet enter the realm of the possible.)

Besides, Activity folk point out, SAE interest *always has been* much higher on papers which deal with design problems faced by the members two-to-three years before the product description is released . . . papers which deal with engineering and design fundamentals, with materials selection, and with operating problems. And they see more and better papers on the horizon in all practical-to-the-designer categories.

Automobile Assembly Line Lingo

baby bath — The well lining into which the convertible top folds.
backlight — Rear window.
banjo — Rear axle housing.
barrel clip — A tubular retainer for attaching ornaments to body panels.
bathtub — A cup shaped recession into which an ornament is attached.
belt rail — Instrument panel assembly.

SUSTAINING MAN in space requires an ambient pressure of 5 psia, with a desired oxygen partial pressure of at least 3.8 psia. This conclusion is based on an extensive investigation of



EFFICIENT SEATING of passengers is an important economic aspect of airplane design. This is especially true for the likely-to-be-developed supersonic transport — forcing designers to look hard for acceptable ways of increasing passenger density. The illustration shows how three popular compacts and a business transport aircraft might fit inside an SST transport. Although this is not a workable arrangement it does imply the possibility of achieving better seating.

chips

from SAE meetings, members, and committees

the literature, made in connection with the Mercury capsule program. It was also determined that the oxygen consumption rate (allowing for suit leakage) would be 500 cc/min at standard temperature and pressure, and the CO_2 production rate is 2.6 lb per day. Water production rate of the human being was taken as 6 lb per day, and heat production rate is 400 btu hr.

GETTING OIL, gas, and coal out of the ground and distributing them to users, requires nearly 10% of the energy the U.S. gets from all sources, records Ethyl's John Wintringham. Another 15%, he says, is used to convert the energy from its original form into a form some user needs. . . . The largest single use of energy is for residential and commercial heat and power (21.6%). Transportation, farming, and other automotive purposes use just over 18% — mostly as gasoline. Just under 18% of the energy is used in industrial processing . . . and non-fuel uses of energy (including making petrochemicals from petroleum) account for a little over 7%. Railroads and miscellaneous uses take another 11%.

STEAM COOLED ENGINES were used in the late 1930's by United Parcel Service for multi-stop package delivery vehicles. These vehicles were operated for ten years with no sludge or dilution troubles and almost unmeasurable cylinder bore wear. Standard commercial 4- and 6-cyl engines were used. Fan and water pump were not used . . . but a finned tube condenser was mounted on the roof.

TRUCK ENGINE COOLING systems are required to transfer as much as 540,000 Btu/hr . . . about four times the rated heating capacity of a home furnace.

THE SPIRIT OF ST. LOUIS III, a 4-jet bomber which the Air Force recently flew at bullet speeds from Fort Worth to Paris via the transatlantic route of Lindbergh's historic flight, symbolizes the "computer age" of aviation, SAE member Milo F. McCammon said recently.

First and only supersonic bomber of the Strategic Air Command and holder of six world's speed records, the B-58 Hustler bomber is the first aircraft that would be impossible for man to fly without a complex power control system that "thinks ahead" for the pilot. Heart of the control system is a computer and the entire system was born in a computer before the aircraft itself was designed.

McCammon described the Hustler's computer-born-and-directed "power thinking" control system as "the most amazing combination of electronic, electro-mechanical, and hydraulic devices in any manned aircraft."

It operates, he said, by continually sensing and computing all aerodynamic effects on flight of the supersonic plane and instantly translates the pilot's control-column movements into just the right amount of actual control-surface motion.

The control system begins in the needle-like nose of the delta-wing bomber where sensing units pick up data on the plane's air environment — air speed, air density, temperature, aircraft attitude (or posture) and other vital information, McCammon said.

A "central air data computer instantaneously and continuously evaluates this information, then relays appropriate control through a complex power system capable of exerting 7,500 times as much force as that required in a late-model commercial airliner.

"There is no difference in control 'feel' to the pilot, even though the actual control-surface action varies from a motion of 2½ ft at relatively low speed to only 1¾ in. at high speed," said McCammon.

COOLANT TEMPERATURES from 260–300 F were used in American and foreign aircraft engines after World War I using a solution of water and ethylene glycol. At these high temperatures fuel consumption was reduced 8–11%.

GOOD OLD DAYS? . . . Remember when permanent anti-freeze used to cost about $10 a gallon?

A 75-HP 2-STROKE SPARK-IGNITION ENGINE operating at wide-open throttle consumes about 40 gal of oil in 100 hr, whereas a 4-stroke engine of the same size may never use 40 gal of oil in its lifetime. The large amount of oil burned in the combustion chambers of 2-stroke engines causes them to be more sensitive than 4-stroke engines to oil quality.

THE UNITED STATES BUILT 93% of all the world's civil aircraft during the days of piston-engine planes, according to Najeeb Halaby, head of FAA; whereas we build only 50% of the world's jet aircraft.

BRAKES RUN COOLER with cast wheels than with disc wheels. Tubeless tires result in cooler running brakes than tube tires.

Digest-listing of NEW and REVISED

S • Standards

A • Recommended Practices

E • Information Reports

. . . Scheduled for 1962 SAE Handbook, these digest-listings mark the start of a new monthly service to SAE Journal readers. (Aerospace reports and standards will be included in future listings.)

EVERY NEW AND REVISED report scheduled to appear in the 1962 SAE Handbook is digested in the following list. Specific notation appears on those few reports which have been approved by the SAE Technical Board since September, 1960, but which are to be published in other-than-Handbook form.

This complete listing *begins a new SAE Journal service to readers,* which will be kept up-to-date on a monthly basis from now on. Each month SAE Journal will digest the new and revised reports which have been approved by the four Councils of the SAE Technical Board. Then, in September, 1962, SAE Journal will publish a complete list of all new and revised reports scheduled to appear in the 1963 SAE Handbook.

Included in the monthly listings will be reports approved by the Aerospace Council of the SAE Technical Board. These are published separately as SAE Aerospace Material Specifications (AMS), SAE Aerospace Standards (AS), SAE Aerospace Information Reports (AIR), and SAE Aerospace Recommended Practices (ARP). These do not appear in the SAE Handbook.

SAE Journal readers will thus be kept up-to-date on additions to and revisions of all SAE Technical Board-approved reports, standards, and recommended practices. When no digest-listing appears in a given month, the reader is safe in assuming that no reports have been approved since the previous issue . . . and there will be some such months because SAE procedures tend to bulk official approvals in particular months.

Automotive Council

George J. Huebner
Chairman

REVISED: AGRICULTURAL TRACTOR AUXILIARY POWER TAKE-OFF DRIVES-SAE J717 — The spline section was revised to correspond exactly with dimensions specified in the *1000 RPM Power Take-Off for Farm Tractors* report. (Tractor Technical Committee)

REVISED: AGRICULTURAL TRACTOR POWER TAKE-OFF DEFINITIONS AND TERMINOLOGY-SAE

Continued on next page.

J722 — Reaffirmed without change. (Tractor Technical Committee)

REVISED: AGRICULTURAL TRACTOR TEST CODE-SAE J708 — Hydraulic equipment must now operate at all times during the test. Zero Dynamometer Torque Test replaces Minimum Dynamometer Torque to eliminate variations produced by driving accessories through the PTO. Ballast definition was broadened to include mounted equipment. (Tractor Technical Committee)

REVISED: AUTOMOBILE WIRING-SAE J556 — Recommendations on usage of low-tension wire having a precalculated resistance to limit voltage have been incorporated. No wire specifications are given because of current design variations. (Electrical Equipment Committee)

REVISED: AUTOMOTIVE FLASHERS-SAE J590 — A slight revision accommodates the turn signal pilot indicator provision in the *Turn Signal Lamps* report. (Lighting Committee)

NEW: AUTOMOTIVE PAINTING PRACTICES-SAE J761 — Current surface coating practices of the automotive industry are covered. Discussions on cleaning, chemical treatment of surfaces, primers, and color coatings are included. *Note*: This report will not appear in the 1962 SAE Handbook. However, it is available as TR-191, Automotive *Painting Practices-SAE J761*. (Nonmetallic Materials Committee)

NEW: AUTOMOTIVE PRINTED CIRCUITS-SAE J771 — Describes the composition and properties of printed circuits used in low-voltage, low-current instrument applications, classifies printed circuits, and provides test procedures. (Electrical Equipment Committee)

REVISED: AUTOMOTIVE TRANSMISSION TERMINOLOGY-SAE J645 — The only change is in the definition of the term hydrostatic transmission. (Transmission Committee)

REVISED: AUTOMOTIVE V-BELT DRIVES-SAE J637 — Revisions are aimed at drawing the attention of designers to differences existing between pulley groove dimensions in SAE and industry standards. (Engine Committee)

REVISED: AVERAGE VEHICLE DIMENSIONS FOR USE IN DESIGNING DOCKING FACILITIES FOR MOTOR VEHICLES-SAE J699 — Provisions are made for tubeless as well as tube tires. (Transportation and Maintenance Technical Committee)

REVISED: BATTERY IDENTIFICATION SELECTION CHART-SAE J781 — New battery types having cavities molded at the ends of the container bottom (to accommodate bottom hold-down mountings) have been recognized. *Note*: This report will not appear in the 1962 Handbook, but will be included in the next editions of TR-33, *Electrical Equipment Booklet* and of TR-200, *Storage Batteries*. (Electrical Equipment Committee)

REVISED: BRAKE TEST CODE — INERTIA DYNAMOMETER-SAE J667 — The test procedure was simplified and made more indicative of current industry practice. (Brake Committee)

NEW: CLEARANCE ENVELOPES FOR TRUCK SIDE OPENING POWER TAKE-OFFS-SAE J772 — Covers dimensions of envelopes for regular duty, side opening PTOs. The report is applicable to chassis clearance immediately adjacent to the PTO side openings on truck transmissions. (Transmission Committee)

NEW: CRANE LOAD STABILITY TEST CODE-SAE J765 — Determines the maximum capacity of a crane that will counterbalance loads applied on its hook block. Crane capacity is reported in terms of the load in pounds and its corresponding radius in feet for a specified position of the superstructure with respect to mounting. (Construction and Industrial Machinery Technical Committee)

REVISED: COMMERCIAL VEHICLE DISC WHEELS-SAE J694 — Three new bolt sizes were added and three overall rim sizes modified. (Truck and Bus Technical Committee)

NEW: DIMENSIONAL SPECIFICATIONS FOR GENERAL SERVICE SEALED LIGHTING UNITS-SAE J760 — Contains dimensional specifications for 5¾- and 4½-in. sealed lighting units. The 4½-in. lamps are used extensively on earthmoving equipment. (Lighting Committee and Construction and Industrial Machinery Technical Committee)

REVISED: EMERGENCY REFLEX REFLECTORS-SAE J774 — Prescribes a number of tests for devices used on roadways to warn approaching-vehicle drivers of stationary hazards by reflecting light from approaching-vehicle lamps. (Lighting Committee)

REVISED: HIGH TENSION IGNITION CABLE-SAE J557 — Two types of suppression ignition cable were incorporated in view of increased use by vehicle manufacturers. Included are specifications on the conductor, insulation, braid and sheath, plus various performance tests. (Electrical Equipment Committee)

REVISED: HYDRAULIC FLANGED TUBE, PIPE AND HOSE CONNECTIONS. 4-BOLT SPLIT FLANGE TYPE-SAE J518 — Specifications for the large flange clamp sizes (3, 3½, 4, and 5) have been added for maximum working pressures up to 500 psi. These sizes are used at the inlet ports of large pumps. (Construction and Industrial Machinery Technical Committee and Tube, Pipe, Hose and Lubrication Fittings Committee)

REVISED: HYDRAULIC POWER PUMPS-SAE J744 — Specifications for a new size F mounting flange have been added and some of the dimensions for the key revised. (Construction and Industrial Machinery Technical Committee)

REVISED: INCANDESCENT LAMP IMPACT TEST-SAE J603 — Test requirements have been added for 1683-type lamps. (Lighting Committee)

REVISED: LAMP BULBS AND BASES-SAE J569 — More realistic dimensions and better filament and base contact identification are reported. Filament spacing and tolerances for tail-stop bulbs have been added. (Lighting Committee)

REVISED: LAMP BULBS AND SEALED UNITS-SAE J573 — Reports changes in filament dimensions for types 55 and 57 bulbs. Information on construction and industrial machinery type lamps has been extracted and placed in another report. (Lighting Committee)

NEW: LIGHTING IDENTIFICATION CODE-SAE J759 — Provides for a coding system which manufacturers may use to identify lighting equipment meeting SAE Standards or Recommended Practices. (Lighting Committee)

REVISED: MOTOR TRUCK INSTRUMENT PANEL GROUPING-SAE J680 — Recommends that tractor protection valve control be located on right side of steering column. See new Tractor Protection Valve Control report. (Truck and Bus Technical Committee)

REVISED: MOTOR VEHICLE SEAT BELT ASSEMBLIES-SAE J4 — Upgraded to an SAE Standard in recognition of broad industry acceptance. Other changes: Increase in minimum webbing tensile strength from 3000 to 4000 lbs; and increase in webbing elongation test requirement from 25% maximum under 2250 lbs to 25% maximum under 2500 lbs. Added to the report were webbing abrasion requirements (similar to MIL-W-4088C (USAF) and Federal Specification JS-B-185a), plus requirements for color and light fastness. (Motor Vehicle Seat Belt Committee)

REVISED: PASSENGER CAR TRAILER COUPLINGS-SAE J684 — The present Class B (2,000–5,000 lbs.) has been subdivided into two new classifications . . . because of an increase in the number of trailers of this size now in use. Drawings of the fixtures used to establish hitch ratings were added along with specifications on safety chains. The report has been upgraded to an SAE Standard. (Trailer Hitch Committee)

REVISED: **REFLEX REFLECTORS-SAE J594** — Minor changes were made in the setup for testing section to reflect new approval procedures used by certain states. (Lighting Committee)

REVISED: **SAFETY PRACTICES FOR MECHANICAL VAPOR COMPRESSION REFRIGERATION EQUIPMENT OR SYSTEMS USED TO COOL PASSENGER COMPARTMENTS OF MOTOR VEHICLES-SAE J639** — Updated to reflect current practices in labeling air-conditioning units. (Motor Vehicle Air Conditioning Committee)

REVISED: **SEALED LIGHTING UNITS FOR CONSTRUCTION AND INDUSTRIAL MACHINERY-SAE J598** — An extensive revision reflects the use of 4½-in. headlamp and floodlamp units on earthmoving equipment and off-the-highway vehicles. (Lighting Committee and Construction and Industrial Machinery Technical Committee)

REVISED: **STARTING MOTORS-SAE J542** — Nomenclature and dimensions are clarified. (Electrical Equipment Committee)

REVISED: **STORAGE BATTERIES-SAE J537** — Incorporates six new battery types along with their electrical requirements. (Electrical Equipment Committee)

REVISED: **TIRE CHAIN CLEARANCE-SAE J683** — Expanded to include drop center as well as conventional tire sizes for both single and dual truck wheels. (Truck and Bus Technical Committee)

NEW: **TRACTOR PROTECTION VALVE CONTROL-SAE J779** — Recommends a uniform method of operation to increase safety and prescribes approximate dimensions and valve location. Use of a single procedure will simplify driver training. (Transportation and Maintenance Technical Committee)

REVISED: **TRUCK TRACTOR SEMI-TRAILER INTERCHANGE COUPLING DIMENSIONS-SAE J701** — Revision affects tractor trailer clearances, maximum attainable fifth wheel location ahead of tandem centerline, and typical combinations of bumper-to-back-of-cab dimensions with 64-in. back-of-cab-to-fifth-wheel dimension. (Truck and Bus Technical Committee)

REVISED: **TURN SIGNAL LAMPS-SAE J588a** — Replaces *Turn Signal Units* as it appears in the 1961 SAE Handbook. In essence, it is a simplified version of the former report which has been broadened to cover turn signal pilot indicators. (Lighting Committee)

REVISED: **12-VOLT LAMP BULBS AND SEALED UNITS FOR HEAVY-DUTY COMMERCIAL VEHICLES-SAE J574** — Revisions affect lamp center lengths (LCL) for type 57X bulbs. (Lighting Committee)

General Materials Council

F. L. LaQue
Chairman

NEW: **AGING OF CARBON STEEL SHEET AND STRIP-SAE J763** — Sets forth problems associated with the aging of carbon sheet and strip steel. It covers hot and cold rolled as well as coated carbon steels. (Iron and Steel Technical Committee)

NEW: **ALLOY STEEL MACHINABILITY RATINGS-SAE J770** — Suggests machinability ratings for SAE alloy steel grades. Machinability ratings are based on a value of 100% for SAE 1112 cold drawn. This value involves turning at a cutting speed of 180 surface feet per minute for feeds up to 0.007 in. per revolution and depths of cut up to 0.250 in., using appropriate cutting fluids with high-speed steel tools, SAE Grade T-1 (18-4-1) hardened to 63/65 RC. (Iron and Steel Technical Committee)

REVISED: **ALUMINUM ALLOYS-SAE J451** — The temper designation section was deleted. (Nonferrous Metals Committee)

NEW: **ALUMINUM CASTING ALLOY REPORTS** have been reorganized into three new reports: *SAE Aluminum Casting Alloys-SAE J452, Chemical Composition of SAE Aluminum Casting Alloys-SAE J453,* and *Mechanical and Physical Properties of SAE Aluminum Casting Alloys-SAE J767.* Containing new and revised data, they are presented in a more concise manner. (Nonferrous Metals Committee)

REVISED: **CHEMICAL COMPOSITIONS OF SAE ALLOY STEELS-SAE J404** — Attention is called to the existence of related alloy grades in SAE Aerospace Materials Specifications and Military Specifications. Also, grades 6120, 9262, and 9850 have been deleted. (Iron and Steel Technical Committee)

REVISED: **CHEMICAL COMPOSITIONS OF SAE CARBON STEELS-SAE J403** — A new carbon steel grade, SAE 1044, has been added. (Iron and Steel Technical Committee)

REVISED: **CHEMICAL COMPOSITION OF SAE WROUGHT ALUMINUM ALLOYS-SAE J455** — Three new grades were added: SAE AA5086, AA5083, and AA5456. (Nonferrous Metals Committee)

REVISED: **DIESEL FUELS-SAE J313** — The revision provides equipment designers with technical information on diesel fuel properties and characteristics. A brief summary of material published by other organizations is included. (Fuels and Lubrications Technical Committee)

REVISED: **DIMENSIONAL TOLERANCES OF SAE WROUGHT ALUMINUM ALLOYS-SAE J458** — Provisions are made for new SAE grades AA5086, AA5083, and AA5456. (Nonferrous Metals Committee)

NEW: **ENGINE POPPET VALVE MATERIALS-SAE J775** — Details properties and other characteristics of materials used for engine poppet valves. Also establishes an SAE numbering system based on functional applications. (Iron and Steel Technical Committee)

REVISED: **ESTIMATED MECHANICAL PROPERTIES AND MACHINABILITY OF HOT ROLLED AND COLD FINISHED CARBON STEEL BARS-SAE J414** — Information on two carbon steel grades has been added, SAE 1044 and SAE 1047. (Iron and Steel Technical Committee)

REVISED: **FIBERBOARD TEST PROCEDURE-SAE J315** — Dimensional stability is recommended as the best criteria for evaluating warpage characteristics for panel board. (Nonmetallic Materials Committee)

REVISED: **FLEXIBLE FOAMS MADE FROM POLYMERS OF COPOLYMERS OF VINYL CHLORIDE-SAE J15** — Flame test method added, air oven aging and compression set added to Table 1, *Basic Requirements.* Nomenclature and grade numbers related to

Continued on next page.

identification values revised. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

REVISED: **GENERAL CHARACTERISTICS AND HEAT TREATMENTS OF STEEL-SAE J412** — Information on two carbon steel grades has been added, SAE 1044 and SAE 1047. (Iron and Steel Technical Committee)

REVISED: **GENERAL DATA ON SAE WROUGHT ALUMINUM ALLOYS-SAE J454** — Repetitive text is now presented in concise tabular form. A new table on typical characteristics of SAE Wrought Aluminum Alloys added. (Nonferrous Metals Committee)

NEW: **HARDENABILITY BANDS FOR CARBON H STEELS-SAE J776** — The appearance of SAE 1044H and 1047H in the 1962 Handbook marks the beginning of an entirely new series of hardenability bands which will be augmented from time to time by other broadly used carbon steels. It parallels the existing H-bands for alloy steels. (Iron and Steel Technical Committee)

NEW: **LATEX DIPPED GOODS AND COATINGS FOR AUTOMOTIVE APPLICATIONS-SAE J19** — Classifies (by physical properties) dipped goods and coatings made from compounded latex. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

REVISED: **LATEX FOAM RUBBERS-SAE J17** — Nomenclature is improved and compression deflection values made more meaningful. Compression set test is also clarified. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

NEW: **LIST OF FORMERLY STANDARD SAE ALLOY STEELS-SAE J778** — Is a compilation of those alloy steels which, because of decreased use, have been deleted from the SAE Handbook since 1936. Along with a steel's chemical composition, the corresponding AISI designation is given. (Iron and Steel Technical Committee)

REVISED: **MAGNESIUM ALLOYS-SAE J464** — The report has been consolidated and made more concise. (Nonferrous Metals Committee)

REVISED: **MAGNESIUM CASTING ALLOYS-SAE J465** — The report has been consolidated and made more concise. (Nonferrous Metals Committee)

NEW: **MEASUREMENT OF STRESS BY X-RAY-SAE J784** — Considered from both technical and practical points of view, techniques are presented which enable satisfactory measurements of stress even when diffraction lines are diffused. Techniques are based on a two-exposure method and on use of diffractometers. *Note*: This report will not appear in the 1962 SAE Handbook, but is available as TR-182, Measurement of Stress by X-Ray. (Iron and Steel Technical Committee)

NEW: **MECHANICAL AND PHYSICAL PROPERTIES OF SAE ALUMINUM CASTING ALLOYS-SAE J767** — Contains material formerly a part of the Aluminum Casting Alloys Standard. (Nonferrous Metals Committee)

REVISED: **MECHANICAL PROPERTY LIMITS OF SAE WROUGHT ALUMINUM ALLOYS-SAE J457** — Mechanical property requirements for stress relieved tempers of SAE wrought alloys were added. (Nonferrous Metals Committee)

REVISED: **NONMETALLIC GASKETS FOR GENERAL AUTOMOTIVE PURPOSES-SAE J90** — Two new grades have been added to Table 2, *Type 2 Cork and Rubber*. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

NEW: **SAE NUMBERING SYSTEM FOR DESIGNATION OF WROUGHT ALUMINUM ALLOYS-SAE J768** — Reflects the increased tendency among both users and producers to identify wrought aluminum by the American Standard Alloy Designation System for Wrought Aluminum (ASA No. H35.-1957). Military Standard 192 covers the same general designation procedure. Thus, the SAE system will be consistent with commonly used procedures. (Nonferrous Metals Committee)

REVISED: **PROCEDURES FOR USING STANDARD SHOT PEENING-SAE J443** — Data added on new "N" Test Strip for checking lesser intensities of peening than those now checked by the "A" and "C" Test Strips. (Iron and Steel Technical Committee)

NEW: **SAE TEMPER DESIGNATION SYSTEM CAST AND WROUGHT ALUMINUM AND ALUMINUM BASE ALLOYS-SAE J766** — Designation system now established as a standard. Is applicable to all forms of wrought and cast aluminum except ingot. Indicated is the sequence of basic operations used to produce the temper. (Nonferrous Metals Committee)

REVISED: **SPECIFICATIONS FOR ELASTOMER COMPOUNDS FOR AUTOMOTIVE APPLICATIONS-SAE J14** — Changes were made to up-date Tables 5 and 6, and accommodate new grades. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

REVISED: **SPONGE AND EXPANDED CELLULAR RUBBER PRODUCTS-SAE J18** — Tables 1, 2, and 3 have been revised. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

REVISED: **TEST STRIP, HOLDER AND GAGE FOR SHOT PEENING-SAE J442** — Addition of new "N" Test Strip for checking lesser intensities of peening than those now checked by the "A" and "C" Test Strips. (Iron and Steel Technical Committee)

REVISED: **TYPICAL PHYSICAL AND MECHANICAL PROPERTIES OF SAE WROUGHT ALUMINUM ALLOYS-SAE J457** — Information on typical mechanical properties for ultimate strength, yield strength, and elongation was eliminated. (Nonferrous Metals Committee)

General Standards Council

G. E. Burks
Chairman

NEW: **AUTOMOTIVE AIR-CONDITIONING HOSE-SAE J51** — Specifications for textile and wire reinforced hoses are given for handling air-conditioning refrigerants. See story on p. 35. (Joint SAE-ASTM Technical Committee on Automotive Rubbers)

REVISED: **AUTOMOTIVE TUBE FITTINGS-SAE J512** — New general and dimensional information on air brake tube fittings of the compression type has been added to provide industry with a means of insuring economy and

interchangeability in air brake systems. Recommendations for certain flange type nuts were revised to make the turned relief on the threaded end option. Angle tolerances for certain fittings are also prescribed. (Tube, Pipe, Hose and Lubrication Fittings Committee)

REVISED: **BALL AND ROLLER BEARINGS-SAE J504** — The 30, 31, and 32 series of spherical roller bearings have been added. These bearings are of similar cross section, and have the same desirable features as Types 22 and 23, but are lighter weight. (Ball and Roller Bearing Committee)

REVISED: **BALL STUDS AND TIE ROD SOCKETS-SAE J491** — Significant changes include the addition of specifications for larger sizes of ball studs used in off-highway applications, new recommendations on tapered and straight shank designs, and conversion of present tabulated values to reflect decimal dimensioning. (Ball Stud and Tie Rod Socket Committee)

NEW: **CONICAL SPRING WASHERS-SAE J773** — Contains specifications for "Belleville" type washers used in the design and fabrication of automotive bodies. Their use will enable designers to obtain the ultimate in performance from sizes specified. (Fasteners Committee)

REVISED: **DRYSEAL PIPE THREADS-SAE J476** — A new Appendix E on Gaging has been added. Tabulated values have been reconciled with other industry standards. (Screw Threads Committee)

REVISED: **FUEL AND OIL HOSES-SAE J30** — A new synthetic rubber tube and cover hose-type completely replaces the present, little-used 30R1 metal lined hose. The performance requirements of other hose specifications have been revised, but still apply to the same basic hose types. (Joint SAE-ASTM Technical Committee on Automotive Rubber)

REVISED: **HYDRAULIC CONTROL SYSTEM FOR AUTOMOTIVE TRANSMISSIONS-SAE J650** — Descriptive and pictorial information on common types of shifting elements has been added. (Transmission Committee)

REVISED: **HYDRAULIC HOSE FLANGED "O" RING CONNECTIONS-SAE J519** — Text and tabulated dimensions have been changed to bring them into line with current engineering practices. (Tube, Pipe, Hose and Lubrication Fittings Committee)

REVISED: **HYDRAULIC HOSE-SAE J517** — Information on spiral wire type construction has been added to SAE 100R2 along with specifications on a new SAE 100R6 hose having a single-fiber braid type construction. (Tube, Pipe, Hose, and Lubrication Fittings Committee)

REVISED: **HYDRAULIC TUBE FITTINGS-SAE J514** — Clarifying footnotes have been added to various tables and editorial changes made. (Tube, Pipe, Hose and Lubrication Fittings Committee)

REVISED: **LEAF SPRINGS FOR MOTOR VEHICLE SUSPENSIONS-SAE J510** — Gage thickness, nominal width dimensions, requirements for the spring loading block, and center cup dimensions have been changed. (Spring Committee)

REVISED: **REFRIGERATION AND MARINE TUBE FITTINGS-SAE J513** — Includes dimensional changes and additions to the present specifications to bring this report into line with changes to ASA B70.1 now under consideration. (Tube, Pipe, Hose and Lubrication Fittings Committee)

REVISED: **RIVETS AND RIVETING-SAE J492** — Minor revisions were made to material and points specifications for small solid rivets . . . and the minimum sharp requirement eliminated from several tables. (Fasteners Committee)

NEW Air Conditioning Hose

Standard is Widely Usable

A NEW SAE STANDARD on Automotive Air Conditioning Hose includes dimensional specifications and performance requirements. The hose covered by the new standard (generally known as "freon hose") has its largest application in mechanical air conditioners for passenger cars. But it is used also for similar systems in buses, trucks, railcars, and aircraft. (Freon hose makes for convenience in "plumbing." Besides, it helps to eliminate noise and failures due to vibration.)

Work on this new standard (product of Subcommittee III-C of the SAE-ASTM Committee on Automotive Rubber) started back in 1957. Almost immediately, it was decided to develop suitable methods for testing the hose, to go along with the dimensional specifications and performance requirements. This was done . . . and the test procedures was submitted to and adopted by ASTM — as ASTM-1680, Methods of Testing Automotive Air Conditioning Hose. (The ASTM test methods standard is suitable for any refrigerant hose, but the SAE dimensional and performance specification apply only to F-12 hose).

Need for this new standard grew out of unfortunate experiences which accrued to early automobile air conditioners, when they came to volume production in the early '50s.

"Some of the early producers," reports Subcommittee Chairman Paul Hopkins, "used whatever hose was available. As a result, they often experienced excessive loss of refrigerant by permeation or effusion through the wall of the hose. Undesirable contamination of the system from foreign material in the bore of the hose was not unusual, either. Sometimes contamination came even from extraction of material from the rubber compound itself. . . . It was this situation which led air conditioner and hose manufacturers to seek SAE-ASTM help in seeking suitable standards."

The SAE standard on Automotive Air Conditioning Hose will appear in the 1962 SAE Handbook. It covers Type A-textile reinforced hose; Type B-wire reinforced hose; hose identification; sizes; sampling; retests and rejections; test requirements; and qualification tests.

Serving with Chairman Paul Hopkins on Subcommittee III-C in developing this new standard were: J. A. Bailey of Goodyear; S. Berthlof of U. S. Rubber; Frank Brown of Boston Woven Hose; W. M. Cline of Aeroquip; C. Coddington of Gates Rubber; L. B. Donkle of Flexonics Corp.; D. Druding of Ford; P. J. Duchin of American Coupling; R. E. Fischer of Chevrolet; I. Kahn of U. S. Army Ordnance; L. F. Klein of Harrison Radiator; E. J. Kvet of Detroit Arsenal; F. J. Lasker of Weatherhead Co.; O. Linger of Goodrich Industrial Products; F. W. Love of Republic Rubber; R. E. Lyons of Anchor Coupling; and W. MacWilliam of General Hose & Coupling. . . . Chairman Hopkins is associated with Electric Hose & Rubber Co.

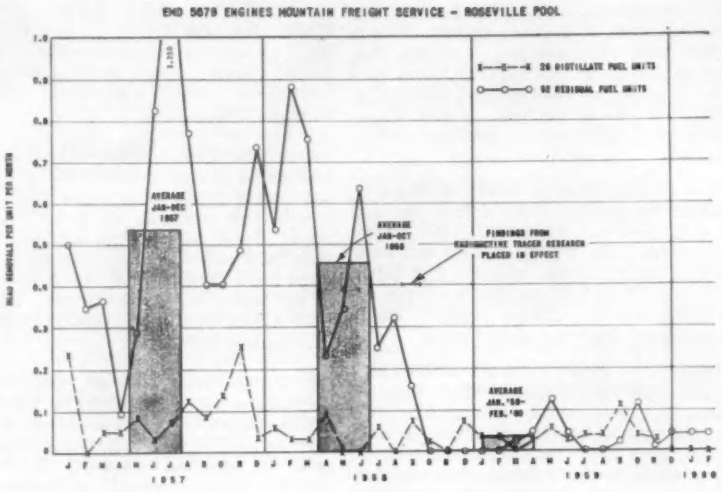


Fig. 1 — Cylinder head removals due to valve leakage, before and after the tracer research findings were applied.

Radioactive tracer research SHOWS

save on maintenance in diesel

Based on paper by

P. L. Pinotti, Standard Oil Co. of California

P. V. Garin, Southern Pacific Co.

D. R. Jones, California Research Corp.

LOWER cost fuels containing residual fractions can now be used with diesel locomotives, without introducing greater wear . . . thanks to recent radioactive ring wear tests. With the improved operation, adopted as a result of the more than 200 test runs, the Southern Pacific Co. has saved an estimated $400,000 per year with its 167 unit residual fuel fleet.

The changes in the residual fuel fleet that brought the improvement were as follows:

1. Replacement of a residual fuel which had a 2.7% sulfur content, by weight, for one having only 1% sulfur content.

2. Engine speed was increased from 800 rpm to 835 rpm to reduce the BMEP at maximum rated power.

3. The engine air filters were changed from the centrifugal separator type to 6-in. thick impingement filters.

4. Filled groove-type cast iron compression rings were used in place of non-filled groove rings.

5. The lubricating oil was changed to one having a long history of succesful use in railroad diesels and which performed well in the radioactive ring wear program.

Just how much these revisions did help is demonstrated in Figs. 1–3, which gives before and after data. Prior to the implementation of the above changes, documented maintenance histories show, residual fuel units had a much higher unscheduled maintenance rate than units using distillate fuel. Then the changes were made in 52 residual fuel units.

Within relatively few weeks a marked decrease in unscheduled maintenance took place. Cylinder head removals due to exhaust valve leakage decreased by 91%. Power assembly removals due to broken or worn piston rings and piston carrier assembly year were reduced by 83%. Because of this success, the same modifications were made to the remaining 115 residual fuel units. Now the same low level of maintenance frequency found in distillate fuel units is achieved in the residual fuel fleet.

Test program

The test program was conducted in three separate phases. First, short-term radioactive ring wear tests in a captive 16-cyl EMD 567C engine were run. These evaluated distillate and residual fuels, lubri-

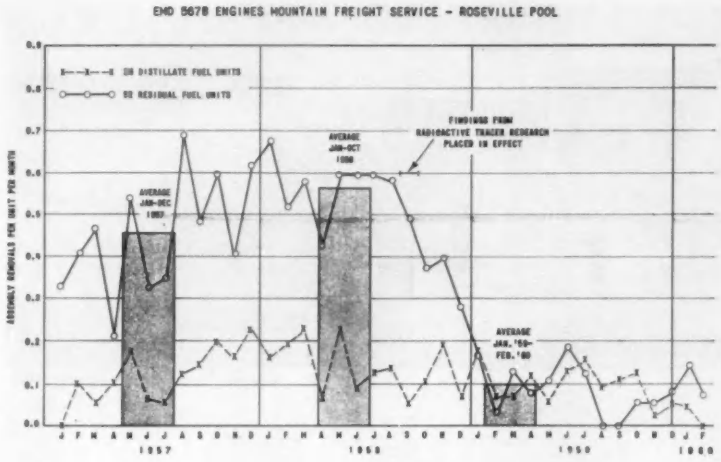


Fig. 2 — Power assembly removals due to broken and worn rings.

HOW to locomotives

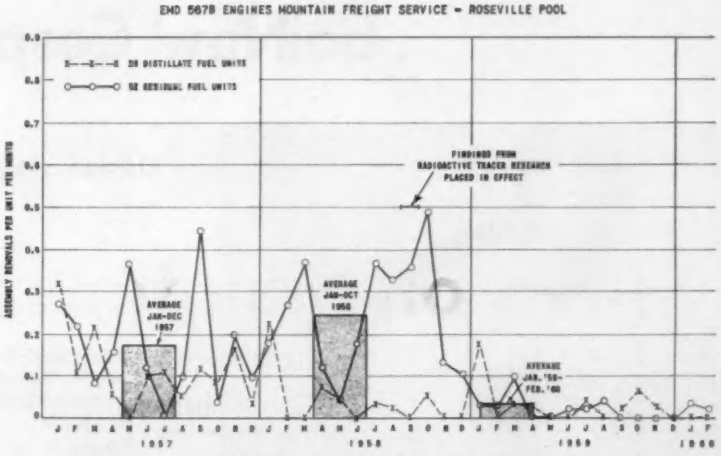


Fig. 3 — Power assembly removals due to high piston carrier assembly wear.

cating oils, operating conditions, engine air filters, and power assembly metallurgy. The data obtained gave information that would have been very difficult to obtain by any other method.

The most important findings from this phase of testing were:

1. Engine load (BMEP) had a marked effect on compression ring wear with both distillate and residual fuels.
2. With chromium plated liners, wear rate of cast iron rings was substantially less than with cast iron liners.
3. Sulfur content was the major fuel property affecting ring wear with both distillate and residual fuels. Below 1.0% the effect of distillate fuel sulfur appeared to be small.
4. A 6-in. thick properly treated impingement-type air filter gave optimum performance.
5. Chromium plating the bottom of the top piston ring groove reduced side ring wear of chromium faced rings by 50% while using residual fuel.
6. A filled groove-type cast iron compression ring gave less wear than an unfilled groove-type ring.

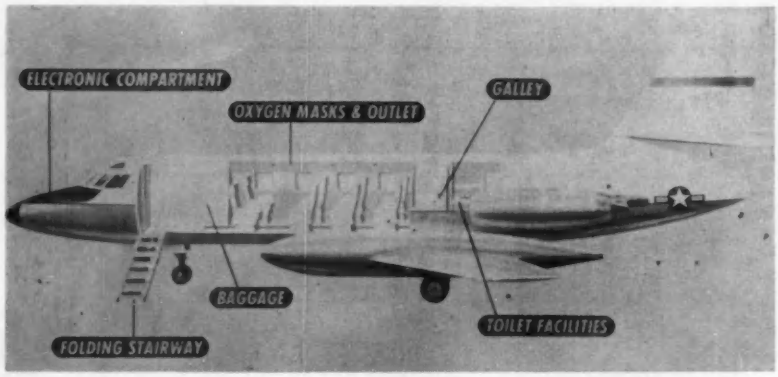
Phase two involved service tests in 27 EMD 567B freight locomotives to study the effects of lubricating oil type and lubricating oil filter design in both residual and distillate fuel locomotives. The lubricating oil from these units was periodically transferred to a captive EMD 567C test engine having radioactive rings for wear measurement.

This portion of the work showed that:

1. By-pass type cotton waste filters provided the best wear protection of four filter types tested.
2. Lubricating oil base number did not correlate with the wear rate of used oils.
3. The type and balance of lubricating oil additives were found to have an important effect on ring wear.
4. A correlation was observed between the wear rate of a used lubricating oil and its n-pentane insoluble content. n-Pentane insoluble level was influenced largely by mechanical factors, including oil filter type.

In the third phase of the program the findings of the radioactive ring wear studies were applied to and evaluated in Southern Pacific's Roseville, California, fleet of residual fuel-burning engines . . . giving the results of Fig. 1–3.

To Order Paper No. 362A . . .
from which material for this article was drawn, see p. 6.



JetStar . . . New Corporate Airplane

Design started—1956; certification—due late

nearly 500 mph speed,

Based on paper by

E. B. Gibson
Lockheed Aircraft Corp.

The JetStar, designed by Lockheed for the corporate airplane market, also aims to meet Air Force requirements for a utility cargo airplane. With this plane, corporate users in the Mid-West can reach the furthermost distance in the United States in less than 3 hr. From Washington to Los Angeles or Seattle requires 4½ hr flying time, with one stop. It can carry a payload-and-furnishings combination of 3567 lb maximum, over a range of 2250 nautical mi. With a normal 10-place interior and payload, the normal mission is 2300 nautical mi. In both cases there would be enough reserve fuel for 45 min of continued cruise.

Powered by four fuselage mounted JT12's, each producing 3000 lb static sea level thrust, the JetStar has a maximum cruise speed of 474 knots at 22,500 ft. Presently, the maximum design take-off weight is just over 40,000 lb and maximum landing weight is 30,000 lb. Total fuel capacity is 2630 gal.

The ceiling at light weight is over 40,000 ft. With one engine out, at maximum power, and at 38,000 lb weight, the ceiling is 29,000 ft. With two engines out at the same weight, with normal power, the ceiling is 17,000 ft. Rates of climb, at sea level, range from 3200 fpm for the heaviest weight, to 5600 fpm for the lightest weight.

For take-off at sea level with maximum take-off weight, approximately 7600 ft are required on a standard day . . . 9700 ft on a hot day. To land at sea level with the maximum landing weight calls for an airport length of some 5000 ft.

Overall length of the JetStar is a little better than 60 ft. Overall height is 20 ft 6 in., and overall wing span is just under 54 ft. The area of the modestly swept wing is only 542.5 sq ft.

As for the direct operating costs, $570 per hour is the anticipated figure, based on 600 hr a year utilization and a trip length of 1500 statute miles. In terms of dollars per statute mile covered, the cost would be about $1.25 a mile for 600 hr per year utilization and distances over 1000 statute miles. For distances as low as 500 statute miles, the cost is still less than $1.50 per mile. This amounts to 15¢ per person per mile for a full load of 10 people.

JetStar systems

FUEL SYSTEM — Fuel is stored in four equal-capacity integral wing tanks and two external wing mounted tanks. The four wing tanks each feed an engine through independent systems. When external tanks are used, they supply fuel to the engines through a crossfeed manifold. Provisions are incorporated on all tanks, both external and internal, for rapid jettisoning of their fuel.

HYDRAULIC POWER — There are two separate hydraulic systems supplied by variable volume pumps driven by the inboard engines. These pumps are backed up by a d-c-motor driven pump for emergency operation. One of the two primary systems supplies operating power for the landing gears,

Typical JetStar interior arrangement. The plane was designed with internal arrangement flexibility in mind, to permit configuration changes for personnel carrying, cargo transport, and training type missions. A 6 ft 1 in. man can walk erect through the entire 28 ft length of the main cabin. Note the engine location, aft and above the wing. In this position drag is reduced and ingestion of runway debris is practically eliminated. Also, the likelihood of crash landing fires are reduced substantially over configurations with wing mounted engines, since the danger of fire from the destruction of the hot engines is minimized.

Material drawn from
SAE Cleveland Section paper

Built With Military In Mind

1961. Features 10 place capability, and 2250 nautical mi range.

gear doors, nose wheel steering, brakes, leading and trailing edge flaps, speed brake, and one-half of the aileron and elevator dual power boost packages. The second system supplies the other half of these boost packages, and provides backup for the landing gear "down," flaps "down," and brakes.

The electrically driven pump is used in a standby capacity during take-off and landing, and supplies power for the dual power boost flight control system and for utility functions.

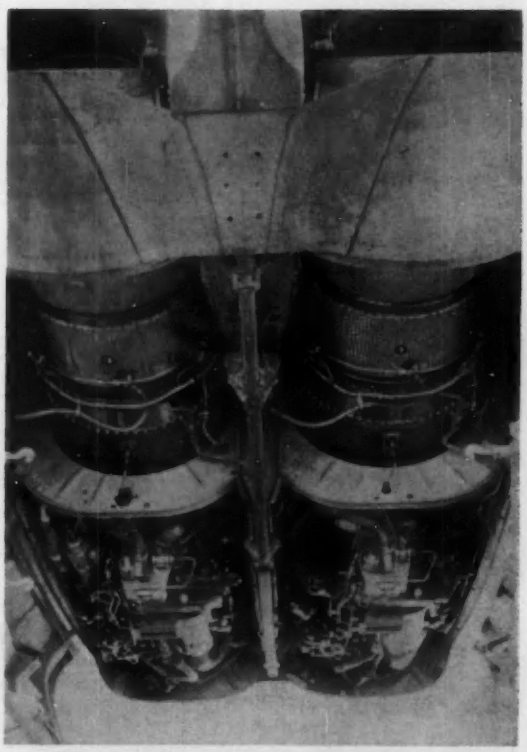
ELECTRICAL SYSTEM — The 28 v d-c electrical system uses four engine driven starter-generators and two nickle cadmium 24-v, 36 amp-hr batteries. A-C power for the electronic units, flight and engine instruments, and windshield anti-icing systems, is provided by three, 3000 va, single phase, 400 cycle, 115-v rotary inverters.

Integral starting is available using the two batteries and the starter-generator on each engine.

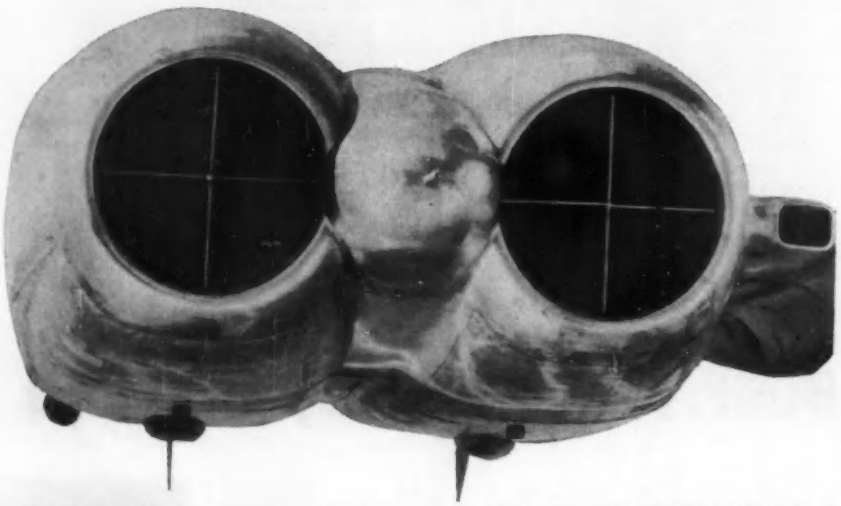
PNEUMATIC SYSTEM — This system supplies engine compressor bleed air from all four engines for:

- Cabin air conditioning and pressurization.
- Wing and empennage deicer boots.
- Anti-icing of the engine inlet duct, guide vanes, bullet nose, and fuel filter.
- Hydraulic reservoir pressurization.

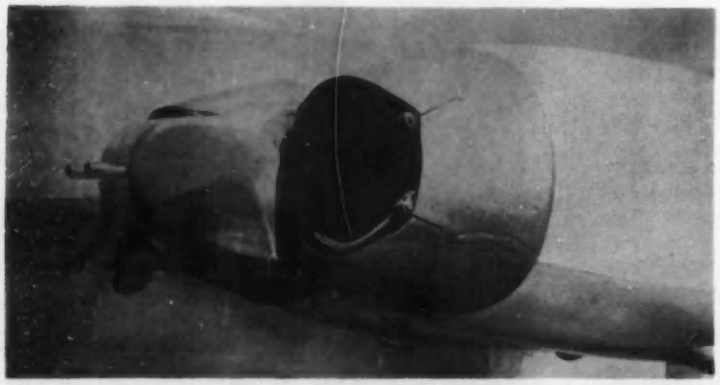
The pressurization and air conditioning equipment is located in the unpressurized section of the fuselage aft of the rear pressure bulkhead. This section is accessible through the opening created by extension of the dive flap on the lower fuselage. Dual air cycle refrigeration units are employed. The



The four engines, and all engine mounted equipment, comprise quick-engine-change units which are essentially identical for all four positions. Large doors on the bottom of each nacelle permit engine installation and removal. The nacelles are isolated from the fuselage, and within the nacelles the engine compartments are completely isolated. For fire protection a continuous type fire detection system is incorporated, along with an extinguishing system.



The simple power plant induction system is designed to obtain total pressure recovery varying from 96% at sea level static, to 99% at lift-off speed with full load, and to better than 99% at cruise.



Simple target type thrust reversers are fitted to all four engines. Flight test show that they can save 600 ft of landing field length at maximum landing weight. In the normal flight position (top) the reversers form the after fairing of the nacelles. In the extended, or reverse thrust, position (bottom), the reversers deflect the exhaust forward, above and below each pair of nacelles. In the event of a single engine failure, the remaining three engines can be placed in full reverse without the large assymetrical yawing loads normally encountered on airplanes with wide-spread, underwing, podded arrangements.

limiting differential pressure of 8.8 psi provides an 8000 ft cabin altitude at 45,000 ft.

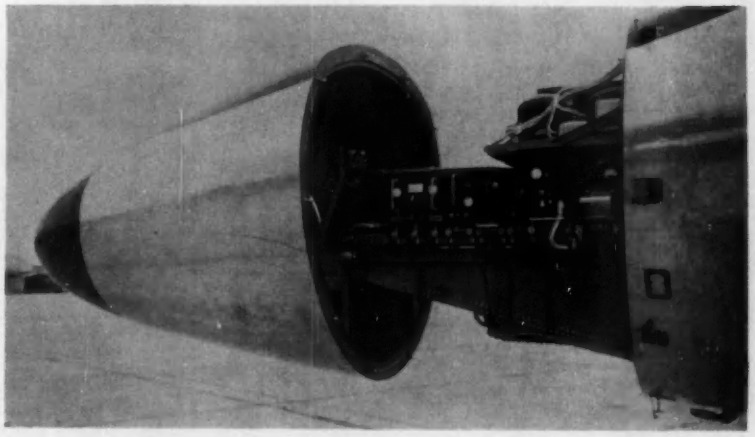
Electronic equipment in the pressurized nose is cooled by a controlled air flow which exhausts overboard. A fan provides ground cooling for all the electronic equipment.

Wing and empennage ice protection is provided by a high-pressure snap action pneumatic boot system. Windshield anti-icing and defogging, as already noted, is accomplished by heating the panels electrically.

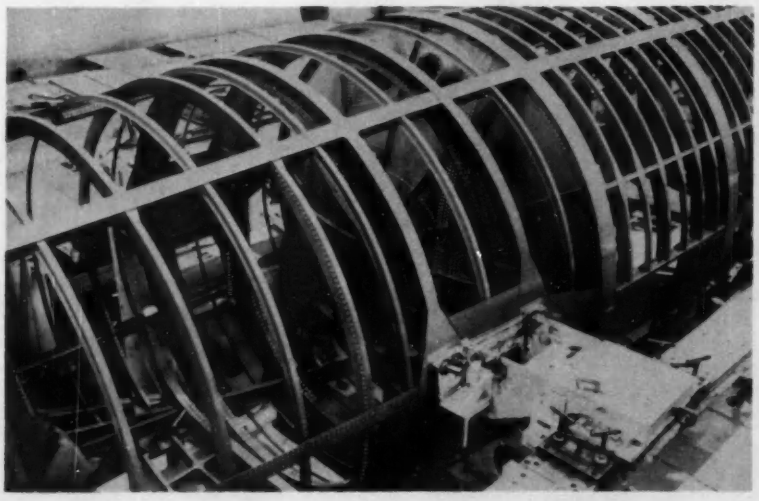
FLIGHT CONTROLS — A dual cable system using dual tandem hydraulic boost for elevators and ailerons, and a linked tab boost for the rudder is employed. Boost ratios are approximately 3.0 for the elevator and 8.5 for the ailerons. The no-load surface rates are 81 deg per sec for the elevators and 46 deg per sec for the ailerons. No special damping systems are needed on any axis.

The secondary flight controls are also conventional and consist of trim subsystems, speed brake, wing flaps, and droopable leading edges. All of the trim controls are powered with dual screw-jack actuators. The longitudinal axis trim system uses two drive motors to permit emergency operation, completely independent of normal control. Both the trailing and leading edge flaps utilize multiple screw-jack actuators on each section.

To Order Paper No. S310 . . .
from which material for this article was drawn, see p. 6.

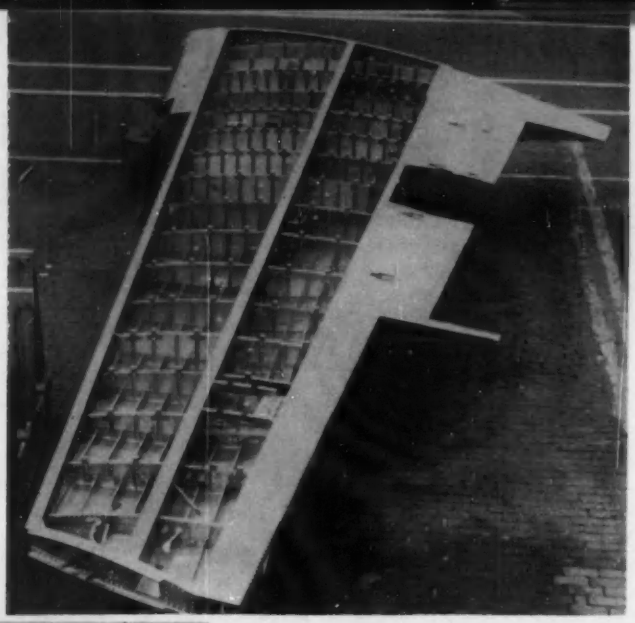


The pressurized nose cone contains the complete communications, navigation, radar and integrated flight systems equipment. The light exterior shell of skin, frames, longerons, and radome material, is supported on tracks, from internal structures, cantilevered from the foward pressure bulkhead. These structures serve as racks for the electronic equipment. The nose shell can be unlatched and rolled foward about 40 in. for service; or it can be removed completely.

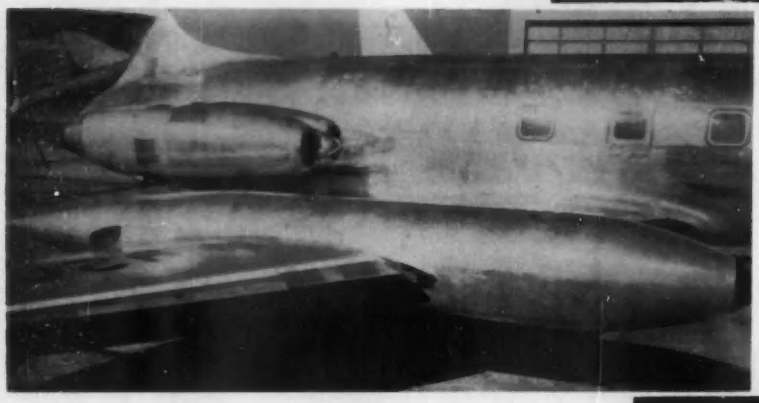


The fuselage is mainly of convention longeron, ring, and skin construction. Fail-safe structural design is used throughout. The two heavy frames in the aft fuselage section, just behind the pressure bulkhead, provide for the mounting of the power plants. The jig shown here is used to locate the pod attach fittings. Wing loads are carried through the fuselage by five heavy, press-forged frames, providing maximum head room in the cabin with minimum cross-sectional area of the fuselage.

See pages 42 & 43

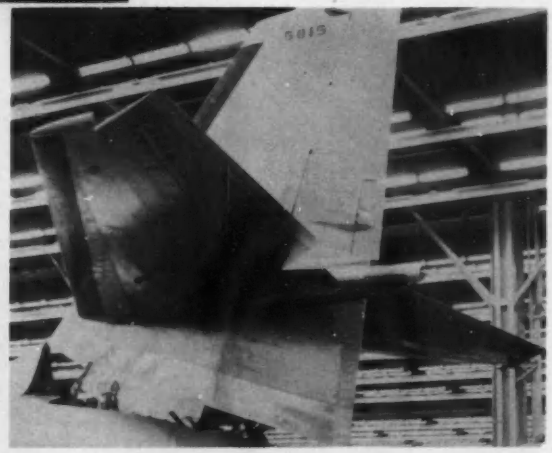


The wing is of conventional box beam construction, utilizing aluminum alloy extrusions and sheet. The three shear webs are located on element lines. The integrally stiffened skins fuel-seal the entire box, to form two fuel tanks in each wing.

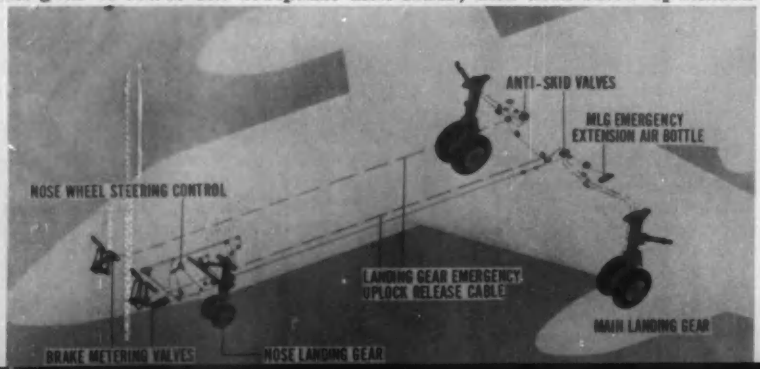


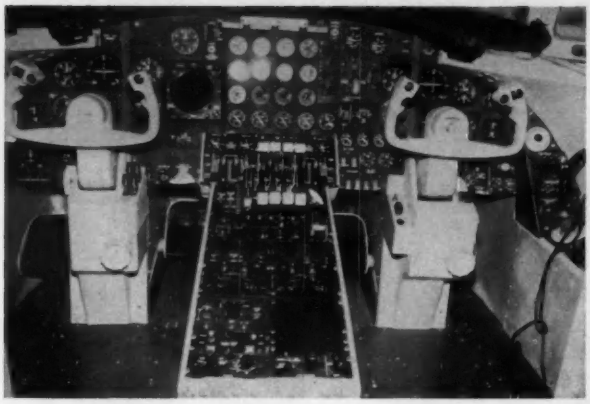
Wing leading edge in drooped position. Extended chord, power operated, droopable leading edges are provided over the outer 60% of the wing to assure maximum lift coefficients. Tests have shown that this also provides good stall warning. The wing mounted external fuel tanks slip glove-like over the wing from the front and attach to internal wing fittings with bolts. An aft fairing slip on from the rear and attaches to each tank. The tanks themselves are sheet skin, rib, and longeron structures.

The empennage structure is a conventional two-spar, skin and rib structure for the fixed surfaces, and single-spar, skin and rib structure for movable surfaces. The entire empennage forms a single assembly which pivots about a hinge fitting on the rear beam of the vertical fin. The assembly is actuated by a fail-safe electromechanical dual actuator to provide the required trim. Note the deicer boots on the leading edge of the empennage.

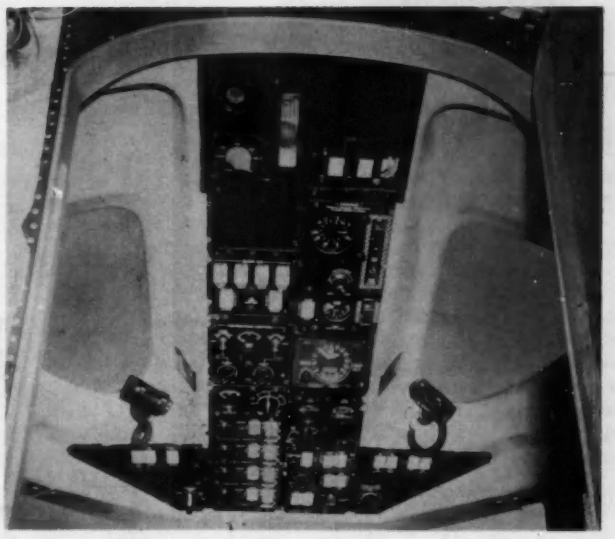


The landing gears are conventional in design and are hydraulically actuated. Dual wheels are used on each gear to lower the footprint unit loads, and thus allow operation in a wide range of airfields. The nose wheels are steerable and the main gears have brakes on all four wheels, with anti-skid provided. The emergency brakes are fully powered with utility hydraulic system emergency pressure.

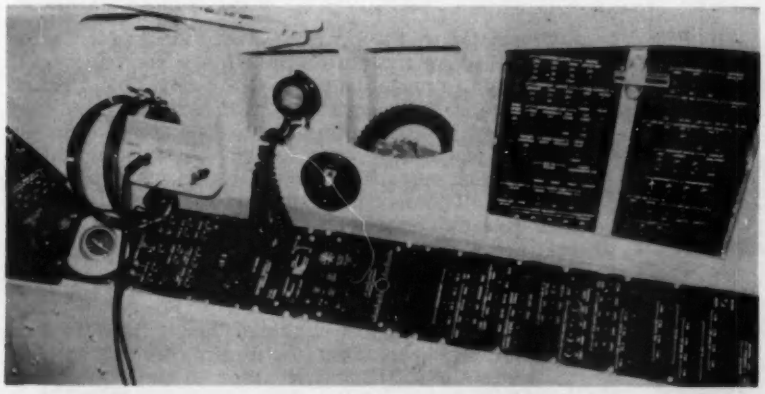




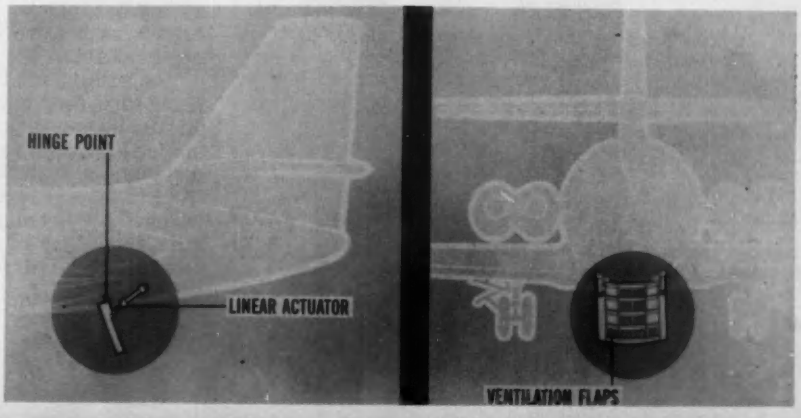
Conventional primary flight controls are used on the JetStar. The instruments, switches and other controls are arranged on seven panels. The main panel, shown here, presents pilot's and copilot's flight instruments, engine instruments, fuel management controls, landing gear controls, and automatic warning lights. The engine throttles, thrust reverser controls, flap control lever, trim switches, speed brake switch, autopilot controls, and essential electronic controls are all mounted on the pedestal between the pilot and the copilot.



The overhead panels contain the cabin pressurization and air conditioning controls, electrical system controls, secondary electronic controls, and lighting and engine deicing controls.



The side panels contain oxygen regulators, controls for the deicing system and intercommunications, map case and data case. The side wall panels provide mounting for circuit breakers and fuses.



The presently used speed brake is hydraulically actuated; has a maximum travel of 60 deg, and travels at a rate of 13 deg per sec. The hinging is simple. Dual linear actuators are used.

Material drawn from an
SAE Texas Section Paper

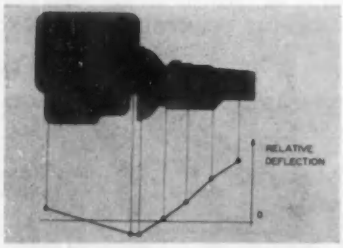


Fig. 1 — **Peugeot 404 powerplant** bending vibrations excited by vibrator at the rear mount. First mode is 130 cps.

How Peugeot studied

Based on paper by

Rene Bouquet
S. A. Automobiles Peugeot

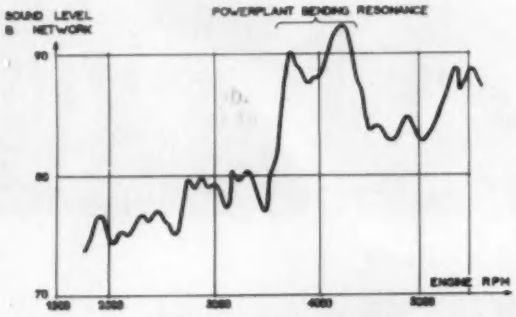


Fig. 2 — **Sound level in center front seat.** Car driven on chassis dynamometer in third gear with full throttle.

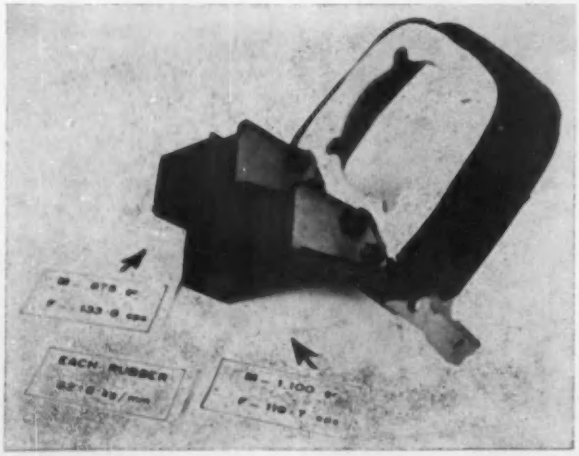


Fig. 3 — **Rubber block rear mount affixed** to two metallic brackets. One is bolted to gearbox, the other on floor.

TO INCREASE passenger comfort and reduce material and fatigue failure caused by strains induced by vibration, Peugeot undertook the study and isolation of car vibration and noise in its 404 model.

Fig. 1 shows the bending vibrations in the Peugeot 404 powerplant, a 4-cyl engine, tilted at 45 deg. Secondary inertia forces provide a resonance around 130 cps (4000 rpm). The rear of the gearbox vibrates diagonally and its vibrations excite the floor. As shown in Fig. 2, these vibrations are the cause of a peak in noise curve because they excite a body cavity resonance of the body.

The noise was unbearable in the first prototypes. Trying to give the clutch housing more rigidity did not raise the resonance over 4600 rpm. To get rid of the noise in the normal range of car speed it would have been necessary to go over 5500 rpm. Another solution would have been to place the rear mount at the node of vibration. Construction made this impossible. The solution finally reached was to place a double dynamic absorber vibrating in the same plane in which the engine was tilted.

Design of sound silencer

The rear mount is a rubber block fixed to two metallic brackets. One of these, shown in Fig. 3, is bolted to the gearbox, the other to the floor. The absorber consists of two different masses supported by rubber blocks with frequencies of 133 + 8 and 119 + 7, respectively. Fig. 4 shows the reduction in noise obtained with this absorber.

The equipment used included a Swiss-made magnetic tape recorder which recorded noise and speed on the same tape, and a Moseley recorder which made it possible to draw a noise-versus-speed curve directly. A third octave and octave analyzer gives the evolution of the noise spectrum when the speed varies. A dynamic analyzer of Peugeot design permits recording of certain frequencies (the fundamental of a pair of gears in the gearbox, for in-

noise reduction on its 404 model

stance) whatever the speed may be. It is essentially a very narrow filter, the center frequency of which is maintained proportional to the speed of the car through rather complicated servo links.

Body response to vibrations

To ascertain whether or not mechanical vibrations in the range of 100–1000 cps, which can be generated by the powerplant, gearbox, driveshaft, or rear axle, were amplified by any body panels at resonant frequencies, a completely finished body was isolated from the ground by rubber springs. These have a resonant frequency on the order of 1–2 cps and do not interfere with the higher frequencies encountered in the body of the car. A microphone can be placed inside the car at approximately the location of the passengers' ears.

Fig. 5 shows how vibrations are induced by means of a Bruel and Kjaer low frequency oscillator which controls a Goodman vibration generator. The force applied to the body is measured with a small strain gage dynamometer and Philips strain gage equipment. The applied load is controlled with ±3 lb. Noise inside the body is measured with a General Radio sound level meter and recorded by a Bruel and Kjaer level recorder, the motor of which controls both paper and frequency sweep. Thus, decibel versus frequency curves are obtained.

The force is applied to the body by means of the rear left side shock absorber lever. To stop vibrations in panels, weights are fixed with strong magnets. This makes possible determining the influence of any particular panel on the response curve of the whole body. Then, to separate body cavity resonance noise from panel resonance noise, the car is filled with carbon dioxide. Body cavity resonance frequencies are different in air and CO_2. From the vibration of the response curve one can determine

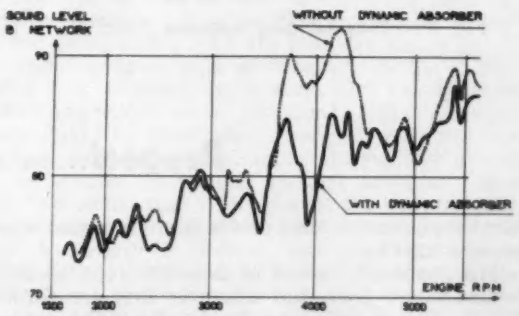


Fig. 4 — **Noise reduction obtained** with use of dynamic absorber under conditions identical with those used to chart Fig. 2.

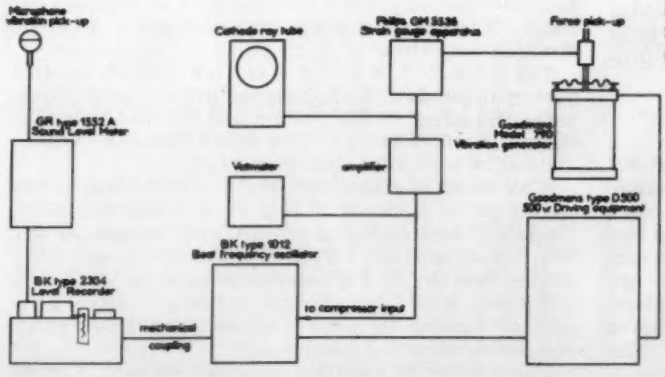


Fig. 5 — **Layout of equipment** used to induce vibrations, and measure and record noise inside the body.

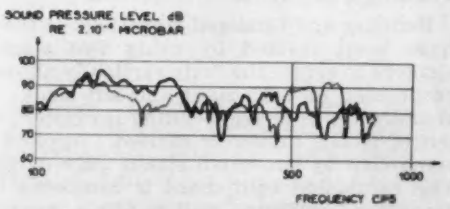
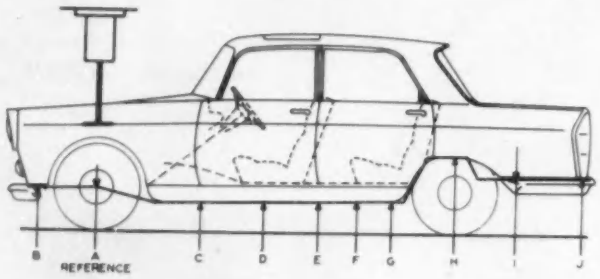


Fig. 6 — **Response curves of two** Model 403 bodies excited at a rear shock absorber (F = ±1.5 kg). Microphone is at rear seat.



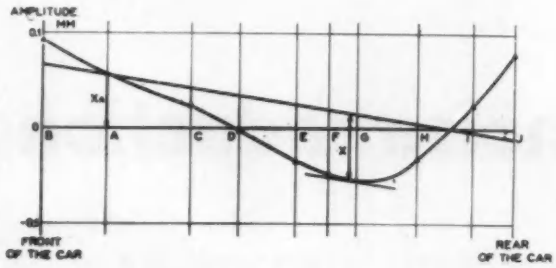


Fig. 7 — **(Above) Body bending** and torsion pickup locations. **(Right) Body bending** amplitudes at 29.2 cps first resonant frequency.

Fig. 8 — **Body bending response** curve of the Model 404.

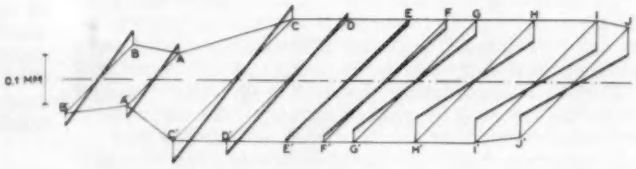


Fig. 9 — **Body torsion** at 34 cps resonant frequency, with node at the center pillar.

Peugeot... continued

what is due to the body cavity resonance and what to panel vibration.

The response curves of two different Model 403 bodies taken from the assembly line are shown in Fig. 6. Panels influence the details of the curve but we have been unable to find out which particular panel was involved. It seems to vary from one body to another, although they are similar in regular production.

Bending and torsional vibrations

Bending and torsional vibrations of the Model 404 have been studied by using two electrodynamic shakers to excite the body vertically above the front suspension on both right and left sides. If the two shakers are in phase, bending is excited; if they are out of phase, torsion is excited. Applied forces are controlled by two small strain gage dynamometers. The excitation equipment is composed of a lower frequency oscillator and a 500-w amplifier. The forces applied on both right and left sides are harmonic forces of ± 33 lb in the range of 10–40 cps.

The measuring equipment records vibration velocities and phase relation at two points at the same time. The Brush, 2-channel recorder records velocities and the dual-beam Tektronic oscillograph records phases photographically. The upper part of Fig. 7 shows the points where measurements are made, with *A* as the reference point. The lower part of Fig. 7 shows the displacements of the various points of the body. Bending deformations are taken from a straight line passing through the maximum displacement of point *A* and the zero amplitude rear point. The deformation is marked *X*, while X_A is the absolute amplitude of point *A*.

The ratio X/X_AZ in Fig. 8 plotted against the frequency depends upon body structure only and eliminates the effect of the powerplant resonance within the range of 10–15 cps. The first resonance in flexion can be seen very clearly at 29 cps.

A torsional resonance at 34 cps with a node at the center pillar is shown in Fig. 9. A lower resonance frequency was found at 22 cps with a node at the front post location. From this study it was concluded that the first resonance in bending, as well as in torsion, were high enough and would not in general be excited by road irregularities, powerplant resonance, or wheel unbalance.

Material in this article is drawn from one of 16 papers included in SP-185 — "Auto Air Conditioning Forum." To order SP-185, see p. 6.

Field experience

shows progress in

GMT-305

gas turbine development

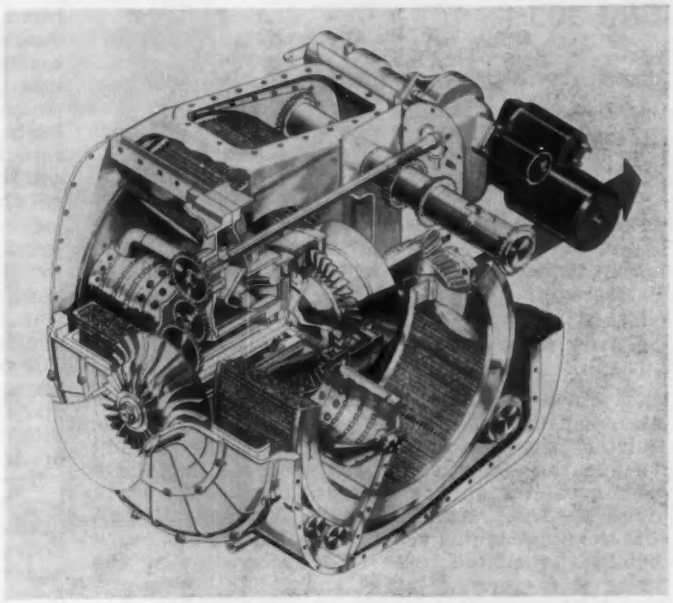


Fig. 1 — **Cutaway view of the GMT-305 gas turbine** designed as a compact unit for vehicular installation.

Based on paper by

R. W. Guernsey

Allison Division, GMC

TESTS of the **GMT-305 gas turbine** in a tracked vehicle, Navy personnel boat, amphibious lighter, wheeled tractor, Navy cyclic generator, and in an off-highway vehicle reveal it to have **four important characteristics** required for military application. These are:

1. **Fast, reliable starting in extremely cold ambients, with very short warmup time.**
2. **Security from detection by sound or visual means.**
3. **Easy operation over difficult terrain.**
4. **Multifuel capability.**

Cold starting of tracked vehicle

Cold room and Arctic tests of the GMT-305 (Fig. 1) in a tracked vehicle showed easy starting with two 6TN-MS 25000 batteries after 24 hr at temperatures as low as – 25 F and with four 6TN batteries at temperatures as low as – 40 F without preheat of either engine or batteries. The engine can be started easily at – 65 F by preheating the engine and four batteries. The engine was ready to move the vehicle as soon as idle speed was attained. However, the transmission would not pick up the load for two or three minutes until the oil pressure was high enough to actuate the clutches (at – 65 F).

Regular engine components with the addition of a suction fan at the exhaust ducts were used for engine preheating. The heating cycle was a preheat for 1 min and a soak for 2 min.

Pertinent data on cold starting are shown in Fig. 2. The time to complete a start and the time to smooth operation were identical. The 18-amp battery charging generator provided with the installation was inadequate, hence the battery would tend to become discharged so that external slave power had to be used. The jog in the current and voltage is due to the operation of a special starting system by which a resistor was used to reduce applied voltage for the first 2 sec. This was done

THE GMT-305 is a free turbine, regenerative engine in the 200-bhp class which resembles very closely the GT-305 regenerative engine described in SAE Journal's April, 1959, article, "General Motors' Firebird III." (A part of this 1959 article was drawn from a paper presented by W. A. Turunen and J. S. Collman.) . . . . Certain changes in mechanical details have been made since 1959 to improve the producibility of a quantity of prototypes; and other changes have been made to adapt some of the engines to particular applications.

to reduce the shock loading of the accessory shafting in the engine which carried starter loading and which tended to become brittle when subjected to extreme cold.

Security from detection

The sound level as a function of frequency with the vehicle stationary is shown in Fig. 3. Under all conditions the turbine powered vehicle was quieter than the standard vehicle. In the running vehicle the reduction in engine noise may have been greater than was apparent because the track noise was the predominant one. At the Arctic test site the approaching vehicle's track noise was heard before the engine noise. Characteristics of the noise at the engine intake and exhaust were determined at various gasifier turbine speeds at a distance of 3 ft from the respective sound sources. With an ambient sound level between 42–53 db, noise levels near the intake and exhaust varied between 97–118 db.

In the desert, sound measurements at idle were made at equally spaced locations at radii of 25 and 50 ft around the vehicle. The average sound level at 25 ft away was moderate (66–73 db) and equivalent to conversational speech at a distance of 3 ft.

Although noise tests with a 28-ft personnel boat have not been completed, it can be stated that the turbine transmitted less waterborne noise than a 200-hp diesel when the mounts were solid. Isolating mounts reduced the noise level for both engines. In this case, at speeds above 0.5 propeller speed the noise created by the boat hull and propeller predominated and masked any engine noise.

A comparative test run with the boat moored and engines running under light load showed that the diesel transmitted more low frequency noise into the water, the turbine more high frequency noise.

Ease of operation

Accelerations were extremely smooth in a given transmission gear range. The shift from one range to another while in motion was of varying quality, but judged to be acceptable to good. There was frequent complaint of lurch when the transmission was shifted from neutral to driving range. Acceleration was very rapid after the initial lag.

On a hard surfaced test track the turbine-powered tracked vehicle could easily pace the standard vehicle. All the driver needed was a brief period of acclimation. At the Arctic test site it was found necessary to keep the gasifier turbine speed above 20,000 rpm to obtain optimum performance for acceleration and steering. This required application of the brakes while the accelerator remained depressed when it was desired to slow the vehicle. The driver's duties were thus made more complicated and there was a tendency to cause more rapid service brake wear. The time required to decelerate (no braking) from a steady state of 30 to 6 mph was 28 sec. This, too, was not conducive to long service brake life and Ordnance personnel recommended incorporation of a hydraulic retarder. Such a retarder worked well in an off-highway vehicle, but a better solution would be to incorporate substantial braking in the engine itself and this is being developed for future engines.

Controls are simple, consisting of an accelerator pedal linked to the gas producer turbine fuel control governor, a fuel shut-off valve, and a starting ignition switch. The fuel control maintained a suitable acceleration schedule automatically. The engine could be operated without many instruments to sense operating conditions. The power turbine has a speed topping device and required no tachometer. Automatic warning of low oil pressure was provided and a light gave indication of regenerator drum stoppage.

The need to keep an eye on turbine inlet temperature indicators on each side of the engine was disliked by operators because of the difficulty of giving them adequate attention when maneuvering under difficult conditions. One solution is to relieve the turbine of sensitivity to high turbine inlet temperatures through conservative design of highly stressed hot turbine parts.

Multifuel capability

The engine performed well on kerosene, JP4, Nos. 1 and 2 diesel fuel, and unleaded gasoline without change of fuel control adjustment. For consistent, optimum operation on various fuels, a few simple externally made fuel control adjustments, such as minimum flow setting, were necessary.

Engine durability

The fatigue failure of turbine blade fasteners through the root of the blade at the top attaching serration was the most serious and damaging of all problems. Fig. 4 shows a typical failure. The best cure is believed to be a fundamental design change to eliminate the serration type fastening. Several test gasifier wheel and blade units have been made by monolithic castings of Inco 713 material. The first two of these have run a combined total of 175 hr successfully and promise a substantial cost saving in addition to doing away with the troublesome fastening.

Oil leaks at various points often delayed test programs. Shaft seals causing the most trouble have been those in the regenerator primary seal rollers. A fix which appears to be satisfactory is to substitute a high temperature grease pack in place of the pressure fed lubricating oil.

There have been a number of leaks at O-ring locations, often due to hardening of the ring materials. A change to materials such as Viton A has been effective in relieving this problem.

The presence of pressure oil passages which pass through split lines has also caused oil leakage. This has occurred in the upper structure of the engine where relatively hot stainless steel parts are mated with the main structural cast aluminum members. Here the problem was solved by substituting an external oil line between front and rear cases.

Combustor dome ills

No. 2 diesel fuel was found to produce a more luminescent flame than JP4 or kerosene. Radiation to the combustor dome caused high metal temperatures which resulted in buckling. The cure here was to change dome design to provide better skin cooling.

Repeated start attempts, due to failure of the engine to accelerate, would cause the 24-v starter to overheat and in some cases burn out. Several short time fixes were employed but a fully satisfactory solution appears to hinge on providing a starter designed specifically to match the turbine starting characteristics.

The tests also made it plain that the gas turbine requires an air cleaner but the size of ingested dirt particle harmful to the engine is still unknown. It appears that damage will result from particles no larger than 70 microns and possibly as small as 10 microns.

To Order Paper No. 383A . . .
from which material for this article was drawn, see p. 6.

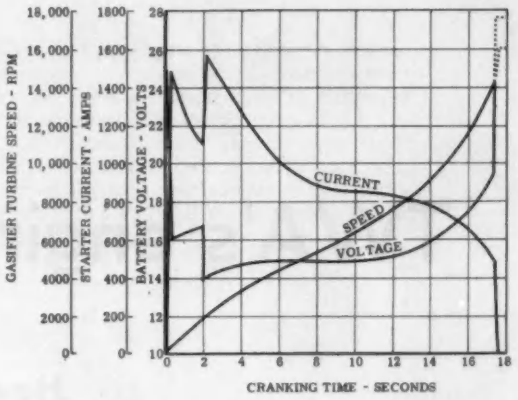


Fig. 2 — **Typical starting values of GMT-305 engine** in tracked vehicle at Arctic test site.

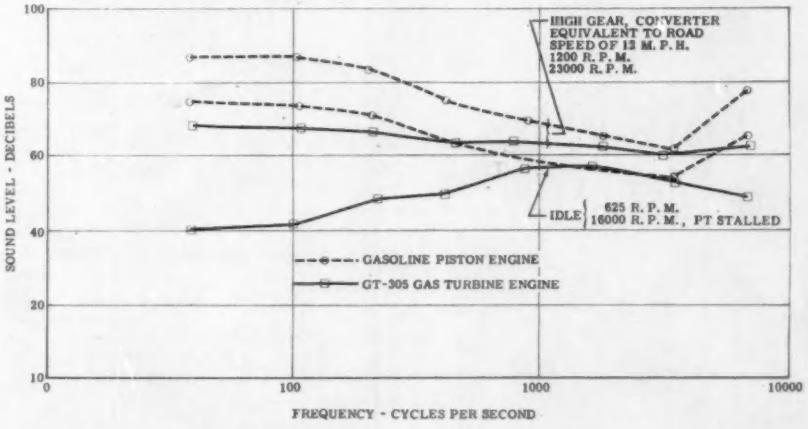

HIGH GEAR, CONVERTER EQUIVALENT TO ROAD SPEED OF 13 M. P. H. 1200 R. P. M. 23000 R. P. M.
IDLE 625 R. P. M. 16000 R. P. M., PT STALLED
GASOLINE PISTON ENGINE
GT-305 GAS TURBINE ENGINE
SOUND LEVEL - DECIBELS
FREQUENCY - CYCLES PER SECOND

Fig. 3 — **Sound level comparison,** static 50 ft to rear center, of tracked vehicles powered by gasoline piston engine and GMT-305 gas turbine.

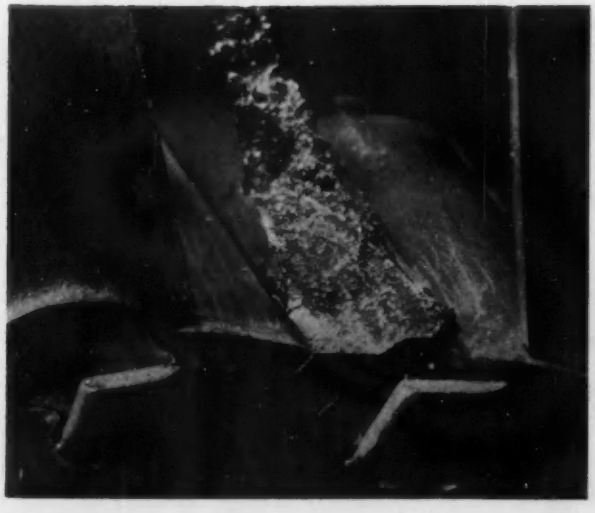


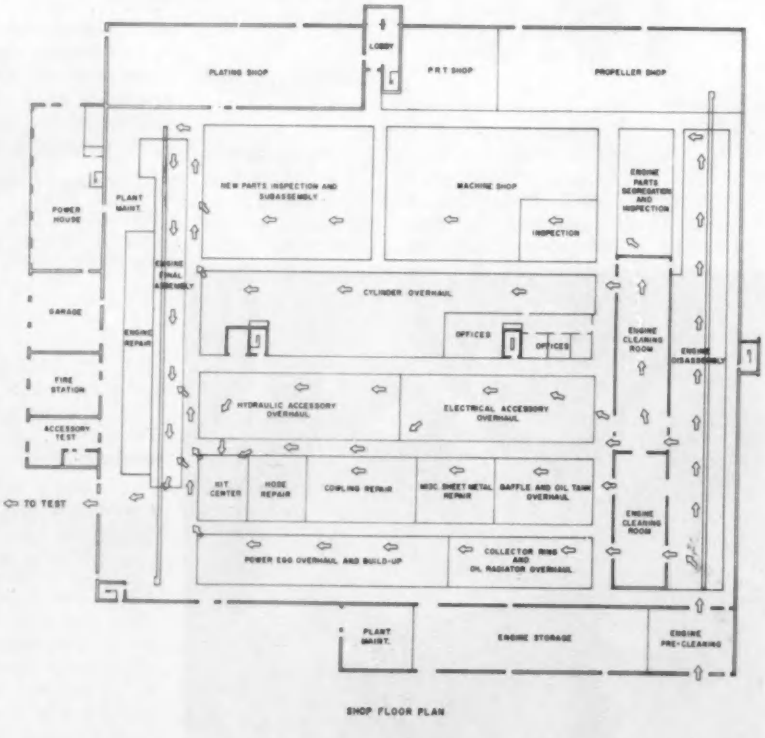
Fig. 4 — **Typical fatigue failure** through root of turbine blade at top attaching serration.

TWA's engine overhaul plant

How transition was made from piston engine to jet within existing plant

Based on paper by

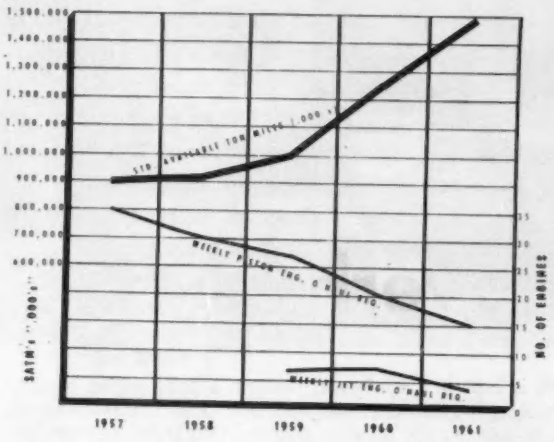
Lee Spruill and T. B. King
Trans World Airlines, Inc.



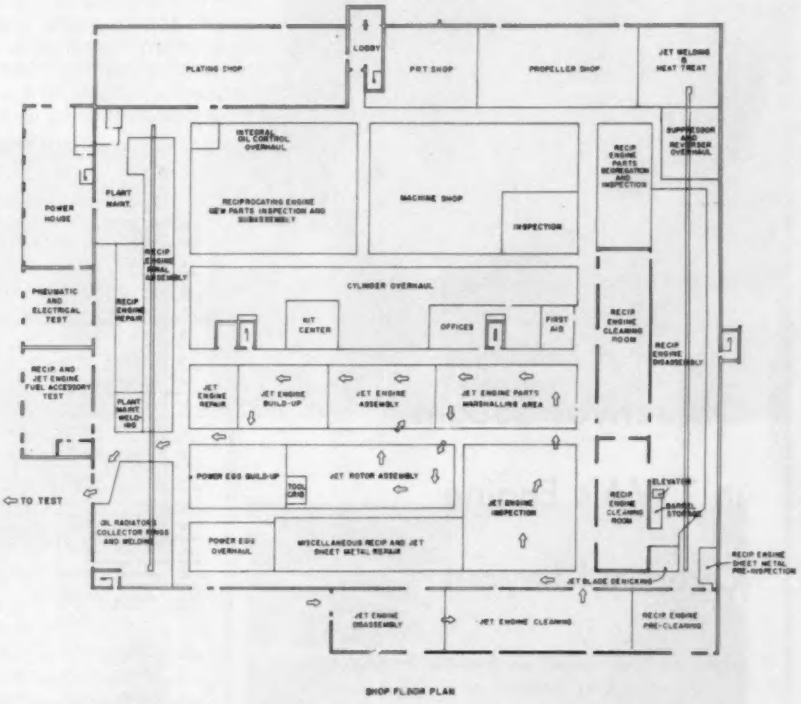
SHOP FLOOR PLAN

SCALE 1/32" EQUALS 1 FOOT

SHOP LAYOUT designed to overhaul seven different model piston engines and 12 different configurations (QEC) at the rate of eight engines per 8-hr day. Engines move from steam cleaning through disassembly on drag line conveyor, with parts being dispersed as shown by arrows. Flow culminates at final assembly, then engines move to test cell. Problem was mainly one of keeping each station work load reasonably constant and scheduling so that right part arrived at the line at the right time.



IMPACT of jet engine operations on shop engine production requirements. Standard available ton miles increased 60% in three-year period as a result of introduction of the fantastically productive jets. During same period, overhaul production dropped 50% because of jet reliability and frequent time extensions, coupled with continued improvement of piston engine reliability.



SHOP FLOOR PLAN

SCALE 1/32" EQUALS 1 FOOT.

OVERHAUL SHOP after revamping to include jet engines. Offices on mezzanine over disassembly line (not shown) were shrunk in and with space acquired from fire house and garage, the total floor space was increased from 145,696 to 166,316 sq ft. Flow of jet engine parts is shown.

THE PAINT was hardly dry on TWA's Kansas City overhaul shop for piston engines when the jet engine made its appearance. Having just spent $5,500,000 on the facility, the management was loath to spend an additional $4,000,000 to accommodate jet engine overhaul. Accordingly, as soon as experience was adequate to predict total overhaul requirements, the plant was revamped to handle both types of engines.

The present jet engine test reject rate is 10%, for piston engines it is 4.5%. The piston engine reject rate dropped from 13% during the past four years in spite of tighter test specifications. A similar drop in jet engine reject rate is expected when the engine becomes better known.

Some of the high spots of the TWA system are revealed here by picture-and-caption travel through the plant.

See pages 52 & 53

TWA's engine overhaul plant

. . . continued

THE KOLENE CORPORATION SCHEDULE

DATE 4/14/61

TRUCKS	CLEAN	INSPECTION	REPAIR	NEW PARTS INSPECTION	SUB-ASSEMBLY	FINAL ASSEMBLY	TEST
JT-A						2239 (6) DUE OUT 4/14	2242 (3) REMAIN DUE OUT 4/14
JT-A						2252 DUE OUT 4/17	
JT-3					2012 (1) DUE OUT 4/14	DUE OUT 4/19	BACKLOG
JT-A					2241 (4) DUE OUT 4/17	DUE OUT 4/20	2240(1) (OVHL)
JT-3					2044 (2) DUE OUT 4/19	DUE OUT 4/24	REPAIRS 2043(1) 2038(4)
JT-A				2234 (1) DUE OUT 4/14	DUE OUT 4/21	DUE OUT 4/26	2250(2)
JT-3			2010 (1) DUE OUT 4/16	DUE OUT 4/17	DUE OUT 4/24	DUE OUT 4/27	
JT-A			2234(3) DUE OUT 4/17	DUE OUT 4/1	DUE OUT 4/25	DUE OUT 4/28	START NEXT 2242(3)
JT-3		2049 (2) DUE OUT 4/7	DUE OUT 4/18	DUE OUT 4/20	DUE OUT 4/27	DUE OUT 5/2	
2048(4) JT-3 DUE OUT 4/6 2221	DUE OUT 4/7	DUE OUT 4/9	DUE OUT 4/21	DUE OUT 4/24	DUE OUT 5/1	DUE OUT 5/4	
JT-A DUE OUT 4/7	DUE OUT 4/8	DUE OUT 4/20	DUE OUT 4/24	DUE OUT 4/25	DUE OUT 5/2	DUE OUT 5/5	

ISSUED BY Production Control

PAPERWORK is kept to a minimum. Here is a daily engine production schedule supplied by the production control group, released the preceding afternoon to show every engine in shop by location and number. As engines are disassembled, accessories and internal parts are identified with metal tags to permit segregation after cleaning This is done to help record keeping of individual parts. No attempt is made to return original parts to same engine after bench inspection. Parts scrambling permits immediate exchange of repairable components for used serviceable components from rotatable stock pool and so reduces in-process time for each engine.

ROTABLE STOCK ALLOCATION AND INVENTORY

Week of 4-24-61

Page 1 of 27

Item No.	TWA Number	Mfg. No. & Description	Code	Weeks Usage	Allow.	On Hand Serv.	Stores Unserv.	In Shop	Remarks
1	368-0150	134403 Sleeve	M	0	6	6	0	0	P
2	368-0195	137263 Washer	P	51	165	43	123	3	P
3	368-0209	139002 Nut	M	12	100	41	57	26	P
4	369-0221	138150 Bolt	M	8	24	1	0	25	P
5	368-0276	145698 Gear	PM	2	16	6	5	5	P
6	368-0281	145053 Plate	M	0	12	6	0	6	P
7	368-0292	170192 Bushing	P	24	120	59	39	8	P
8	368-0295	171075 Shaft	PM	18	110	7	27	75	P
9	368-0300	170481 Bearing	PM	14	30	9	20	3	P
10	368-0306	145150 Support	M	4	16	6	0	4	P
11	368-0326	171.047 Nut	P	90	250	0	0	54	P
12	368-0327	171.096 Bearing	P	6	6	7	1	2	P
13	368-0328	171.09671 Bearing	P	0	6	6	0	0	P
14	368-0553	171.09672 Bearing	P	0	3	3	0	0	P
15	368-0330	171.09673 Bearing	P	0	3	1	0	0	P
16	368-0332	171.096T10 Bearing	P	0	3	5	0	0	P
17	368-0636	171.096T20 Bearing	P	0	3	1	0	0	P
18	368-0353	171344 Support	PM	1	21	14	7	0	P
19	368-0371	172028 Piston	M	0	9	8	0	1	P
20	368-0372	172050 Adapter	PM	4	60	41	0	19	P
21	368-0385	427393 Sleeve	M	1	9	5	0	2	P

P - Purchased Items
S - Items Available only from Shop

Revised 3/26/58,6/10/58,1/12/59, 9/25/59,5/13/60,10/5/60 4/21/61

ROTATABLE STOCKROOM accepts unserviceable parts from bench inspection and forwards a like number of serviceable parts to new parts inspection. Each day, one-fifth of rotatable stock is inventoried and information furnished to machine and plating shops on form shown here. Using this information, schedulers in these shops develop schedules and order from rotatable stockroom the unserviceable units to support schedules. Substantial differences between in-shop figures on inventory and shop records result in physical inventory of in-process parts and correction of rotatable stock records as required.

Objectives Sought in TWA's Engine Overhaul Layout

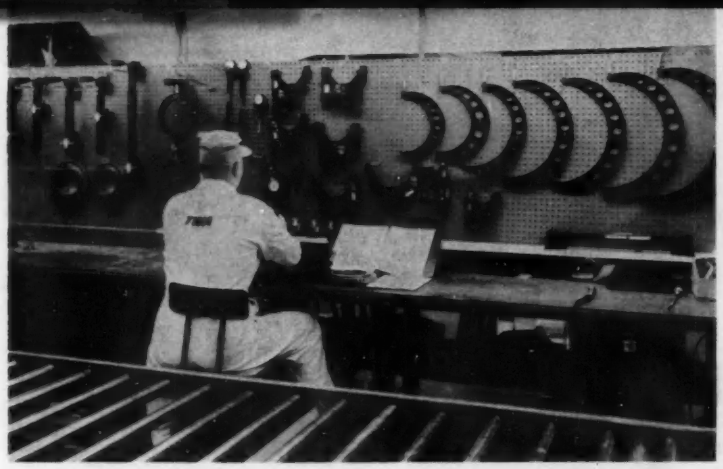
Move as much work as possible by conveyor — bring the work to the man.

Move work in process in the same direction and the shortest possible distance.

Make each shop as self-sufficient as possible. Lathes and other machine tools are located in shops where the volume of repetitive operations provides a reasonably high machine loading.

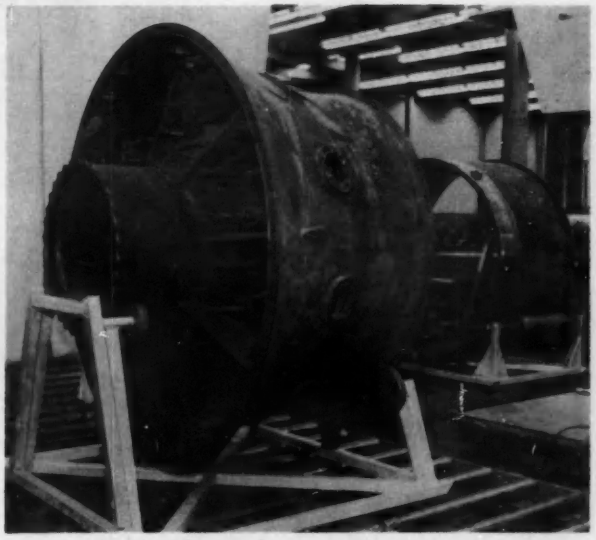
Use conveyors where practical to pace workers and increase productivity.

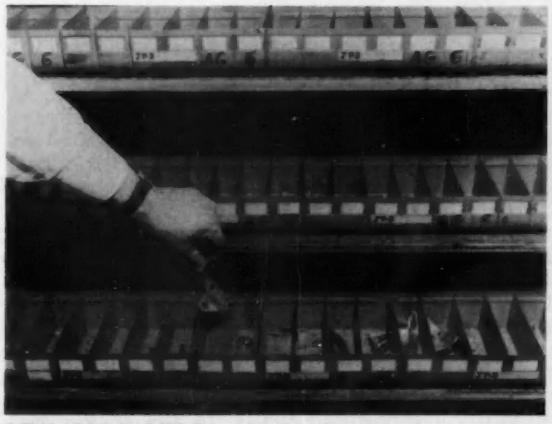
Maintain stocks of normally used parts at each worker's station or bench.



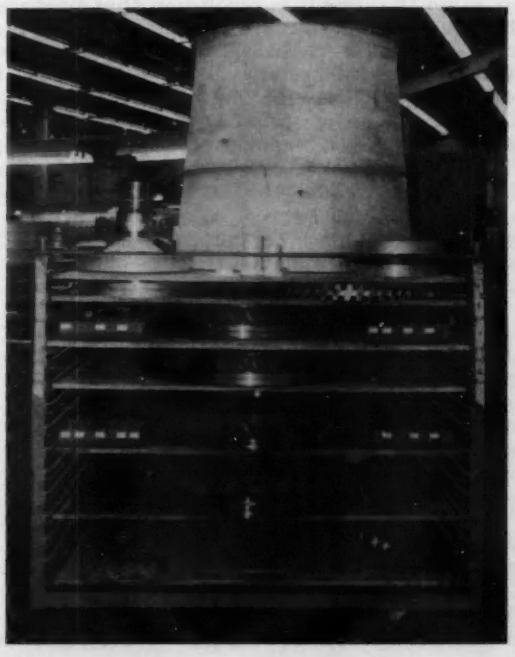
ENTIRE JET INSPECTION is conveyorized. Parts move over conveyors on fixtures and baskets through magnaflux and zyglo functions to specific benches. Mounted on peg boards are all gages and tools needed to perform work assigned to the particular bench.

SPECIAL FIXTURE handles diffuser case which weighs 248 lb. Inspector can rotate case on fixture rollers for complete inspection of entire case.





REUSABLE PARTS from jet teardown are kept separate by part number. When such small parts have accumulated from several engines they are cleaned in a batch by part number. They are then routed to new parts inspection and if pronounced serviceable they replenish bathey bin stock. Each bin compartment is identified by part name and by number for part, assembly group, figure, and quantity per engine.



SMALL PARTS after cleaning and inspection are kitted by assembly groups as each engine is processed through new parts inspection. As shown here, the small parts together with main pieces in each assembly work station complete except for such expendable items as "O" rings and gaskets. Expendable items are kept in bathey bins at each work station.

To Order Paper No. 373C .. . from which material for this article was drawn, see p. 6.

Automotive Engineering:

Reflections and Projections

by

A. A. Kucher

President, Society of Automotive Engineers

THE VAST INCREASE in this century of man's knowledge of the physical world has pushed us to new levels of creative activity. Paradoxically, this new knowledge has led us to the humble conclusions that we really know much less about the physical universe than our grandfathers thought they knew a century ago.

In the less-troubled days at the turn of the century, many technical people felt that practically all of the secrets of the universe had been revealed. Then came the scientific revolution that produced such developments as relativity and quantum mechanics . . . and that supreme confidence was shaken. In the intervening years, we have had to take a fresh look at the thermal, electrical, magnetic, and elastic properties of matter to see how our new knowledge relates to engineering.

This re-examination has had a profound effect on industry by stressing the importance of research.

WHEN IN EUROPE last Spring, SAE President A. A. Kucher gave a two-part message to the four engineering societies which he addressed.

IN PART I, he emphasized the realization of United States' engineers that "technical liaison between European and United States' engineers is vital" . . . and went on with information about SAE "to help overseas engineers better understand what SAE is and how it operates.

THIS ARTICLE is Part II of President Kucher's overseas address.

Until recent years, research was almost exclusively the private preserve of the universities, and development engineering was considered the special domain of industry. Analytical studies were identified with the universities, and intuition and notions were the trademarks of engineering industry. Most of the designs and processes in industry were premised on experience and feel, rather than on precise technical determination and adaptability to manufacturing means.

As an illustration of how this attitude worked in practice, let me relate this harsh but true incident:

In 1918, I got a job as a draftsman with an airplane company that built seaplane trainers for the Navy. Pioneer barnstormers were the chief designers for the company. One day at a bull session someone remarked that an Eastern university was graduating aeronautical engineers and that it was about time to hire one of these experts.

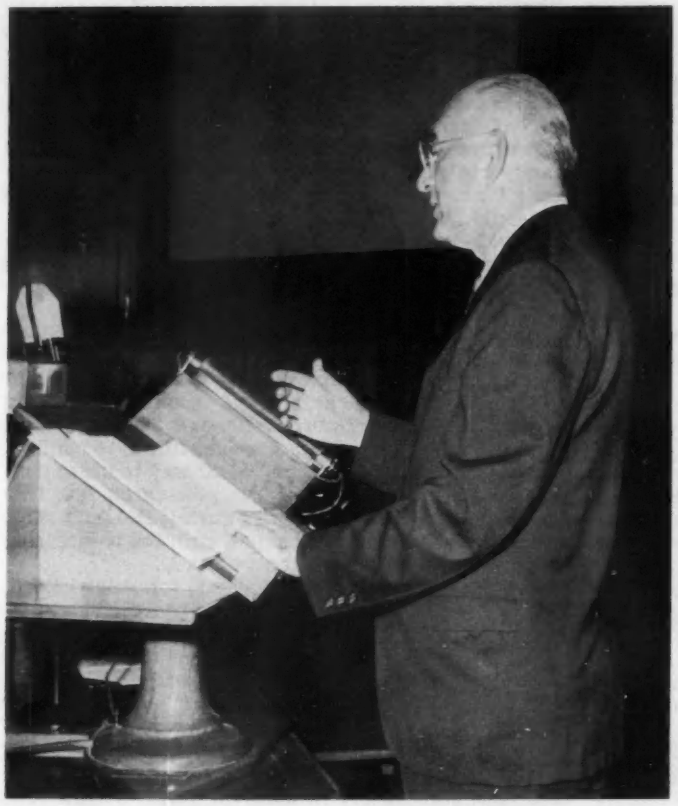
This was done with all the proper decorum, including providing a private office for the Ph.D. in aeronautical engineering.

We were launching on the design of a hydroplane, and the graduate engineer was given the job of designing the empennage. After a couple of weeks, we were ready for the tail section and called in the doctor. He reported that he was getting along fine and had almost completed the vertical fin and rudder.

Pandemonium broke loose and the chief called for a piece of chalk. He got down on the floor and sketched the outline of the fin and rudder. The others in the group suggested putting on a little here and taking off a little there. This process was repeated on the horizontal surfaces. When the group reached agreement, the chief turned to the good doctor and said: "Get a piece of tracing paper — there's your tail section."

The remarkable thing about designing airplanes by intuition is that so many of the pioneers survived their early efforts.

This approach to vehicle development held generally true in the automobile industry during most



In Europe last Spring, SAE President A. A. Kucher addressed the Institution of Mechanical Engineers — Automobile Division in ENGLAND (where this picture was taken); the Société des Ingénieurs de l'Automobile in FRANCE; the Associazione Tecnica dell 'Automobile in ITALY; and the Verein Deutscher Ingenieure in GERMANY.

of its first 50 years. It was possible to design in this manner years ago when a mistake could be caught before it caused too much trouble. Today, however, a major mistake could cost millions of dollars because of greatly increased volumes of production.

We can no longer approach engineering with the idea that it is simply the task of putting the fires out. Technological developments are changing engineering requirements at a faster pace than in any previous era, and we have to approach engineering with a clear, well-coordinated understanding of the task ahead.

Engineers today are being asked for a greater variety of products, faster development schedules, cost-saving engineering methods, and new standards for design simplicity and parts interchangeability.

At the same time, we are being asked for significant improvements in suspending, packaging, and transporting passengers, freight, and instrumentation — and we are asked to give manufacturing and fabricating operations the widest possible latitude in building the ultimate product.

Because of these conditions, the automotive industry has turned to a broad range of research activities, and the knowledge gained in this work is being used to create new cost-saving tools and techniques. Throughout industry, scientific equipment is being employed to great advantage in design, test, and manufacture.

I am not implying that new techniques and equipment will replace trained and skilled technicians and engineers. On the contrary, they are needed more than ever. Good, old-fashioned design ability will remain the key factor in sound engineering. We need engineers and technicians who can produce useful, practical products with a high degree of craftsmanship. New techniques, together with skill and experience, is the combination needed for modern engineering.

These engineers and technicians have a whole new world of materials, processes, and devices to explore.

In the materials field, scientists are learning much about the structure of matter and soon will be able to engineer materials to suit individual needs. There will no longer be any necessity to compromise systems to materials.

Ultra-high-strength steels with tensile strengths approaching half a million pounds per square inch . . . ductile iron-aluminum alloys . . . new alloys of aluminum and silicon . . . titanium-carbide cutting tools . . . metal bonded graphite bearing materials . . . these are only some of the new metals and cermets of the future.

In recent years, the rapidly expanding field of plastics has been giving engineers a good balance of reliability, durability, reasonable weight, and cost, and the time is not far off when even stronger compositions will be available.

In the world of optical materials, research scientists studying glass are finding information that sug-

gests the development of shock-resistant, glass-like materials of great strength.

The development of devices that will perform some of the elementary control functions now handled by the brain is also upon us.

In the field of energy, I think we shall see changes of a revolutionary nature in the uses of energy in future vehicles. We are certain to produce propulsion systems having higher power-to-weight ratios than those of our present engines. Although there is no reason for immediate concern over the future of fossil fuels, it is likely that one day there will be a need for substitute energy sources.

In systems other than familiar powerplants, chemical fuels probably will be converted directly into electrical energy. The most promising device in this area is the fuel cell, which could mean a great advance in the development of electrically-powered ground vehicles and has tremendous promise for space vehicle application.

In the long-range future, nuclear fuels may be a primary source for secondary energy forms. The process of controlling atomic fusion is still a visionary concept, but it holds the promise of producing an almost unlimited supply of low-cost chemical fuels for vehicles.

Just as there will be a wide variety of energy sources to exploit in designing future propulsion systems, there will be specialized propulsion systems in as great a number. The common prime movers today are the jet and the reciprocating engines, but in the future there will be a broad range of energy-conversion systems for various types of vehicles.

In air and space vehicles, jet and rocket engines reign supreme, and their future seems assured. In ground vehicles, the reciprocating engine still is the most efficient means of propulsion, but it has some serious challengers on the horizon.

Among these is the gas turbine. The advantages of a continuous-burning machine have long been recognized, and, with further development, it is destined to be used for many applications in trucks, buses and, possibly, automobiles.

The free-piston gasifier with turbine output offers fuel economy comparable to that of a diesel, and I think this system has a natural adaptability for tractors and earthmoving equipment. The diesel itself is making promising headway in the small engine field and will continue to be used extensively in freight-carrying vehicles. The rotary-combustion engine is an attractive design that may be used successfully when its present problems of internal heat, lubrication, and sealing are overcome.

Hovering over all the internal combustion propulsion systems is a new generation of superefficient, high-speed electric motors. Research in industrial laboratories throughout the world indicates the possibility of developing electric motors of reasonable size and cost with highly favorable power-to-weight ratios. This development should lead to an entirely new family of highway vehicles that will make personal transportation of the future an even safer and more pleasurable experience.

Turning from personal transportation to mass transportation, it seems to me that the time has come for new approaches to moving large numbers of people rapidly. Long-range mass transportation is provided for in the foreseeable future by jet aircraft developments. In the medium ranges of from 100 to 1000 miles, however, no system provides adequate high-speed mass transportation.

A year ago on this rostrum, my colleague, Victor Raviolo, described one approach to this problem — a system I have championed for many years. I am referring to the Levacar, a wheel-less vehicle moving on tracks at speeds between 100 and 500 mph. Our most recent experimental work continues to confirm that this is a practical, economical way to move passengers over medium distances. Research into this system has progressed rapidly during the past year, and I would like to take a few minutes to describe the most recent developments for you.

The Levacar provides means for high-speed, ground, mass transportation for intermediate distances between metropolitan centers, thereby substantially reducing the total travel time as contrasted with air and other modes of travel.

The Levacar is a wheel-less vehicle supported by air bearings, or Levapads, riding on rails. The Levapad provides a near-frictionless means whereby speeds in the range of 100 to 500 mph are feasible. Extensive laboratory testing of pads within this speed range have established technical feasibility for such a system.

Preliminary designs of various vehicle configurations have been made, including a 200-passenger single car design and a 500-passenger segmented train, called a Levatrain.

The Levacar is free from physical contact with the rails, and reaction propulsion is provided by means of turbo propeller units at each end of the vehicle or train, permitting rapid reversal of the vehicles at terminals.

The air supply for the Levapads is supplied by separate turbo compressors delivering air through conduits to multiple pads distributed over the length of the vehicle. We have been improving the design and efficiency of the Levapads constantly during the past year and have reduced the power to levitate the vehicle from 50 to less than 20 hp per ton.

By reason of the uniform distribution of weight over the length of the vehicle, the primary structure is substantially lighter than that of an aircraft fuselage, as the structure of an airplane fuselage depends on the distribution of loads centralized around the main wing spars and empennage.

Currently, the rails are conceived of as 8-in. square sections supported above the ground by stanchions. By reason of the high speed of these vehicles, it is assumed that elevated track structures must be provided through populated areas.

Having established the technical feasibility of the system, we are now engaged in collaboration with some of the major railroad companies in America in studies to establish its operational and economic feasibility.

For spark ignition engines:

better economy . . .

cleaner burning . . .

through stratified charge operation

Renewed interest in stratified charge operation has brought fresh research in this area. Here are the results of some recent work.

Based on papers by

Jean Baudry,
Institut Français du Petrole

Lewis D. Conta,
and

Jose L. Bascunana,
University of Rochester

Pandeli Durbetaki,
Michigan State University

STRATIFIED charge operation is an attempt to realize for spark ignition engines, the advantages of a variable-mixture-ratio that diesel engines enjoy. (In diesel engines the output is reduced by merely injecting smaller quantities of fuel while the air intake stays at the full load value. By using progressively leaner mixtures at the lower outputs, thermodynamic efficiency is increased. Actual engine practice confirms this.) Also, because the stratified charge engine operates with a large amount of excess air under normal conditions, cleaner, more complete combustion can be obtained.

In normal spark ignition engines a nearly homogeneous fuel-air mixture is supplied by a carburetor, ignited at one place by a spark plug, and consumed by an advancing flame front which traverses the combustion chamber. The fuel air ratio is held approximately stoichiometric since only such mixture ratios can reliably support flame propagation. Power is controlled by a simple throttle valve.

The stratified charge engine uses a nonhomogeneous fuel-air mixture . . . stoichiometric near the spark plug at all loads . . . and varying from stoichiometric at full load to air alone at light load in regions remote from the spark plug. The heterogeneous mixture serves to increase the ignition energy so a rapid

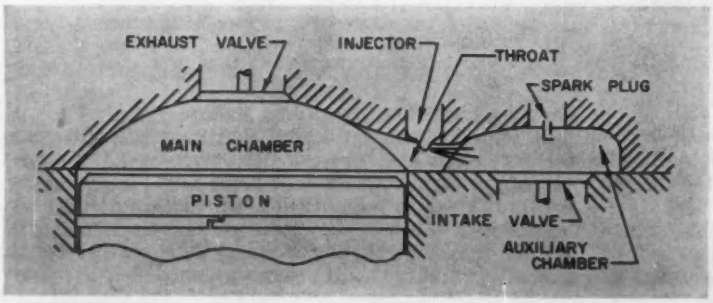


Fig. 1 — Combustion chamber for producing charge stratification by Broderson method.

rate of combustion is maintained and the mixture kept ignitable.

Producing the mixture

Producing the required mixture distribution is the heart of the problem, and several techniques have been used. A method devised by Neil O. Broderson uses a divided combustion as shown in Fig. 1. The auxiliary chamber contains the intake valve, spark plug, and a fuel injector. Operation of the engine is based on the reversal of air flow direction when the piston passes its bottom dead center position.

Fuel injected into the auxiliary chamber during the suction stroke is carried into the main chamber by the incoming air. Fuel injected during the compression stroke is held in the auxiliary chamber by the back flow of air and mixes only with the air in this chamber. At light load, injection takes place only during the early part of the compression stroke. Since no fuel is carried into the main chamber during compression, only air is present there. At higher load the injection period straddles the bottom dead center position so more fuel enters the main chamber. Thus a near stoichiometric mixture surrounds the spark plug at all loads, while the fuel-air ratio in the main chamber varies from near stoichiometric at full load to very lean or only air at light load.

Under heavy load the main chamber contains a flammable mixture and combustion occurs in the normal fashion. At light load, however, the mixture in the main chamber is too lean to support flame propagation. Combustion of this lean mixture results from the pressure and temperature rise caused by the burning mixture in the auxiliary chamber and the blast of the hot reacting gases being injected into the lean mixture from the auxiliary chamber.

A different system, using carburetion to form the heterogeneous mixture, has been developed at the Institut Français du Petrole. The mixture is produced in the combustion chamber by simply dividing the carbureted mixture into two separate streams of completely different fuel-air ratios. Fig. 2 shows an I.F.P. — Renault — CNRS engine modified for heterogeneous carburetion. The only alteration on the engine is the addition of a small diameter tube in the intake port, designed to discharge the rich mixture as close as possible to the intake valve. Experiments have shown that the localized increase of the fuel-air ratio in the vicinity of the spark plug is sufficient to give satisfactory combustion of a mixture of low overall fuel-air ratio.

The Broderson method

Work on the Broderson method has been, and still is, going on at the University of Rochester. Four different engines, converted by amateur designers, have been used to date ... each with a radically different combustion chamber arrangement. They all operated satisfactorily with little or no debugging required, indicating that this method of stratification is not critical with respect to design characteristics. The engines did, however, behave differently in the amount of roughness and noise they produced, and in the spark advance each required. This indicated that combustion chamber design variations can control the combustion process by changing the mixing and turbulence patterns.

All four engines have been relatively insensitive to deviations from optimum values of such operating parameters as spark advance and injection timing. Although off optimum operation results in increased fuel consumption, the engine will still run smoothly with no apparent difficulty.

Very good economy has been obtained over almost all of the load range of the engine. The only exception is a fuel consumption peak in the middle of the load range. A sharp rise is encountered here, apparently at a point where the mixture in the auxiliary chamber is becoming overly rich, and some fuel must be carried into the main chamber. The suspected cause is insufficient turbulence and mixing of the burning products from the auxiliary chamber with the lean main chamber mixture, resulting in slow or incomplete combustion of the main charge. There is a return to good fuel economy as load is increased beyond this region.

Higher compression ratio is a possible means of curing the mid-load range troubles. Changes in combustion chamber configuration to improve fuel distribution and promote turbulence and mixing of the burning gases ejected from the auxiliary chamber with the lean main chamber mixture can also help.

So far only gaseous fuels have been used with these engines, metered by a solenoid injector. Reconversion to liquid injection is planned.

The I.F.P. process

Tests with the I.F.P. engine showed good operation for relative mixture strength ratios (rms = prevailing fuel-air ratio/stoichiometric fuel-air ratio) down to 0.55 and up to a value in excess of 1. The minimum value for normal carburetion, for comparison, is 0.85.

At first the fuel-air ratio was increased by increasing the flow in the rich mixture tube. It was found that specific fuel consumption can exceed the minimum value obtained with ordinary carburetion when the fuel-air ratio exceeds 0.70. A too rich mixture around the plug is thought to account for this.

To avoid this difficulty, an alternate method of changing the fuel-air ratio was tried. Fuel was added to the intake air to get the desired output. This way the heterogeneity of the mixture is lowered as the overall rms value increases. It was found that:

1. The optimum ratio of:

$$\frac{\text{rich mixture tube fuel flow}}{\text{total fuel flow}}$$

decreases with the overall rms value.

2. The requirement for maintaining the optimum ratio at each load are not strict because fuel consumption variations are not large. At full load, the maximum percentage of the total fuel flow that may be fed through the rich mixture tube is 40%. The influence of heterogeneity on octane requirements will affect the maximum percentage.

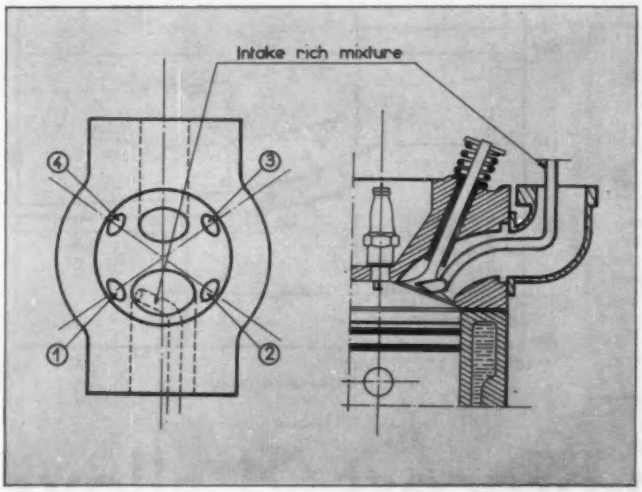


Fig. 2 — I.F.P. — Renault-CNRS laboratory engine modified for heterogeneous carburetion. The numbered openings are for different spark plug positions. Position 1 was the best.

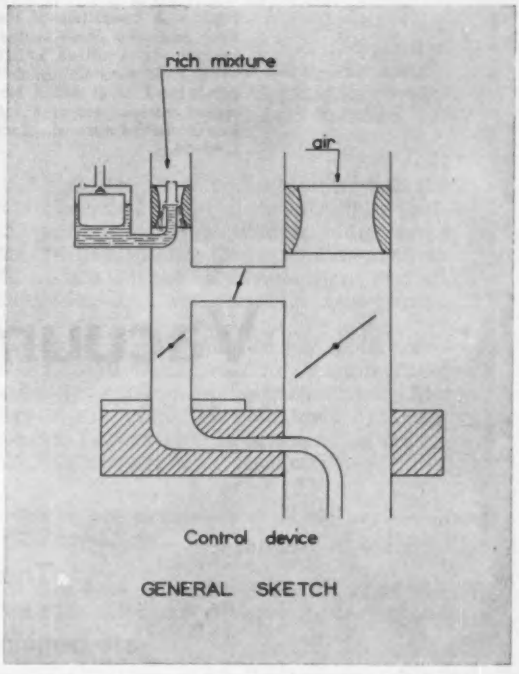


Fig. 3 — Proposed single carburetor induction system for I.F.P. variable fuel-air ratio process.

3. Specific fuel consumptions equal to or better than the minimums obtainable with normal carburetion are achieved with the I.F.P. process. An average of 5% lower sfc was obtained over the minimum consumption when the same engine was operated with normal carburetion.

4. Because the engine can be operated at full load as if it had standard carburetion, no decrease of the maximum output occurs other than that due to decreased volumetric efficiency caused by the presence of the rich mixture tube.

5. Between 50 and 100% load, regulation is obtained by varying the fuel flow only, as in diesel engines. Below 50% load, output is controlled by throttling as with ordinary carburetion. Minimum rms values for stable operation lie between 0.55 for full throttle and 0.65 for idling, but deviations from these values are tolerable — more so than for ordinary carburetion, where rms deviations cause larger increases in the sfc.

Two carburetors were used in the experiments — one for the rich mixture tube, and one for the standard intake pipe. Changes in overall fuel-air ratio and heterogeneousness of the mixture were effected by manual adjustments. In practical applications these adjustments must be made automatically and only one carburetor should be used. A possible solution is shown in Fig. 3. Fuel-air ratio is held constant at part load in the throttling range, by the interconnected butterfly valves. The surface area ratio of these valves is equal to R/r (R = rms of the mixture, r = lower limit of the overall rms). In the unthrottled range, a third butterfly valve directs a portion of the rich mixture into the main induction pipe.

Trouble was anticipated in the form of spark plug fouling due to the rich environment, and deposits in the rich mixture tube — but none was experienced. The lean mixture might ordinarily cause early deterioration of the exhaust valves with normal carburetion, due to slow combustion. With the I.F.P. process, though, as in diesel engines, the problem does not exist because an adequate rate of combustion lowers the exhaust gas temperature in proportion to the decrease in the fuel-air ratio.

With unthrottled operation at fuel consumptions lower than the minima obtained with normal carburetion, no measurable quantity of CO could be found with an Orsat apparatus.

With normal carburetion the CO content of automobile exhaust gases varies greatly with carburetor adjustment and operating conditions. It is negligible only at an rms below 0.95. When the rms is 1.05, a more likely value, the CO content is 2%. At idle it varies from 2–6%. By comparison, the I.F.P. engine was found to have a CO content in the exhaust amounting to 0.008% when idling with partially closed throttle, at an overall ratio of 0.65.

As full load is approached the I.F.P. process approximates the conditions found with normal carburetion and the CO content are the same in both cases. However, reducing the output by 5% would eliminate the CO problem.

To Order Papers Nos. 375B and 380F . . .
from which material for this article was drawn, see p. 6.

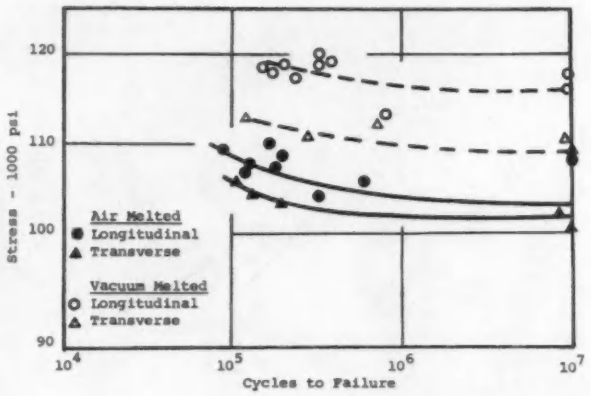


Fig. 1 — A comparison of the fatigue properties of air-melted and vacuum-arc-remelted SAE 6150. (1600 F, 30 min., oil quench, tempered for 2 hr at 840 F for air-melted material and at 855 F for vacuum-melted material. Rockwell C 43–44.)

Vacuum-processed alloys

for tomorrow's automobile

Three now-commercially-available vacuum processes are beginning to bid for attention of automobile designers. Cost-performance elements are detailed here.

Based on presentation by

A. M. Aksoy and P. Lillys

Crucible Steel Co. of America

THREE commercially-available vacuum processes for alloy steels offer quality improvements over air melting which vary in degree with regard to gas content, cleanliness, segregation, hot and cold workability, mechanical properties, and magnetic properties. Equipped with a better understanding of the costs and results of vacuum degassing, vacuum arc remelting, and vacuum induction melting the automotive engineer will be in an increasingly better position to select the process best fitted in a particular case.

It is highly unlikely, for example, that an automobile engineer would at present consider vacuum induction melting or vacuum arc melting for high quality "production" parts such as springs, crankshafts, axle shafts, and others where air melted alloys have performed satisfactorily. But tomorrow, the situation may be different — as the cost of vacuum-melted materials decrease with rising demand.

Right now, in fact, costs of vacuum-degassed alloys are the same or slightly higher than those of air-melted materials — and has the greatest potential for use in the automobile of tomorrow. Vacuum-arc-remelted materials may find only limited use in more critical applications. But the severe conditions encountered in the gas turbine, for example, may require use of high quality materials which can be produced consistently only by vacuum melting . . . particularly in rotating parts subject to high temperatures and stresses where failure of a part could result in extensive damage to the engine.

General applications

Each of these vacuum-melting processes has wide applications.

VACUUM INDUCTION MELTING is best applied to production of high quality products relatively small in size — where composition control is essential.

VACUUM ARC REMELTING is most suitable for large forgings — where sound centers are mandatory; and for quality products of less critical nature.

VACUUM DEGASSING has considerable potential in attaining a quality level better than that attained by air melted materials, but close to vacuum-arc-remelted materials . . . at only a fraction of the cost of either.

In cases where applications of the three vacuum processes may overlap, cost, of course, is the deciding factor.

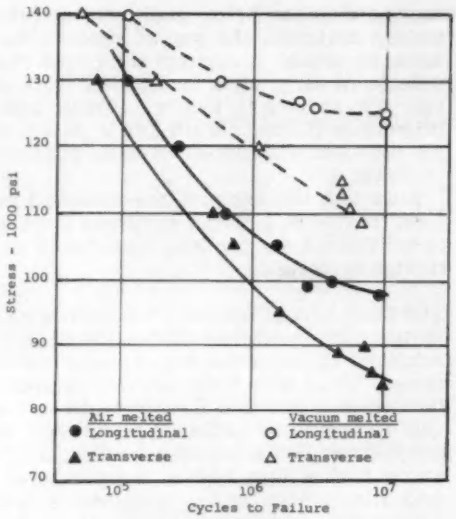


Fig. 2 — A comparison of the fatigue properties of air-melted and vacuum-arc-remelted Nitralloy. (1700 F for 30 min. oil quench, tempered at 1110 F for 5 hr for air-melted material and at 1140 F for vacuum-melted material.)

BOTH AUTHORS of the paper from which this article was drawn have been working actively in the field of vacuum melting processes for a number of years.

Dr. A. M. Aksoy has been in the field of vacuum metallurgy since 1952; was associated with the early developments of vacuum induction melting and vacuum arc remelting.

P. Lillys also has been associated with the development of materials produced by various vacuum melting processes for some time. Since joining Crucible Research in 1951 he has worked on development of constructional, tool, and stainless steel grades.

Dr. Aksoy is chief metallurgist at Sanderson-Halcomb Works, where Crucible Steel Co. has its vacuum melting facilities. **Mr. Lillys** is supervisor of Crucible's Syracuse Research Laboratory, directing activities on high temperature alloy research.

Selecting the right process

Selection of the best process for a particular application will be dictated largely by the alloy, its application and its cost.

Nickel-base superalloys, for example, cannot be satisfactorily melted in air, since they contain a large percentage of reactive elements. They are, therefore, limited to melting in a vacuum.

On the other hand, the vacuum-induction-melting process may be used to achieve optimum quality in alloys for critical applications which normally can be produced by air melting. By combination of the two processes, electrodes can be melted by vacuum induction melting and subsequently vacuum-arc remelted to obtain material for large cross sections.

The vacuum-arc-remelting process, utilizing electrodes made by air-melt practice, can be used to achieve a quality which falls between that of air-melted and vacuum-induction-melted material. Experience has indicated that the quality of vacuum-arc-remelted material, when produced from air-melted electrodes, approaches that of vacuum-induction-melted material. The improved soundness and greater structural uniformity obtained, particularly in large billet cross sections (at considerably lower costs than the double vacuum melting) make this vacuum process widely used for most applications requiring high quality materials.

Vacuum degassing, the newest member of the vacuum processes to achieve commercial status, offers a level of quality better than that of air-melted materials and perhaps close to that of vacuum-arc-remelted materials. Furthermore, the reduction of hydrogen to low levels by vacuum treating permits the production of large ingots free from flake.

The merits of the various commercial vacuum processes can best be understood by examining in detail their relative advantages in terms of performance.

Properties of vacuum processed steels

LOW ALLOY STEELS: Nominal compositions of a group of low alloy steels used in a wide variety of applications are presented in Table 1.

Longitudinal and transverse tensile properties of SAE 4340 made by various melting processes are presented in Table 2. Note that without exception, tensile and yield strength properties are unaffected by melting process. Transverse tensile ductility, as measured by reduction of area, is significantly improved by vacuum-arc remelting and further improved by vacuum induction melting.

Similar trends are observed upon examination of the tensile properties of UHS 260, SAE 6150, and Nitralloy. The only property significantly improved by the vacuum process is reduction of area in the transverse direction. But, the difference in tensile ductility between transverse and longitudinal direction is much less for the vacuum-induction-melted material than for air-melted material.

A comparison of the tensile properties of air-melted, vacuum-arc-remelted, and vacuum-induction-melted 300-M, again shows that only tensile ductility is improved by the vacuum process. On the other hand, the data indicate a considerable improvement in notch tensile strength can be obtained by vacuum melting.

D6 is an alloy steel which is at present being used in large billet cross sections for high strength forgings. Crucible Steel Co. is currently producing this grade by the vacuum-arc-remelting process in ingot sizes up to 32 in. in diameter. Where a direct comparison of ingot to billet reduction is possible, material made by the vacuum-arc-remelting proc-

ess is found to have superior quality (cleanliness, center porosity, and segregation); also, as observed in other low alloy steel grades, higher transverse tensile ductility than air-melted material.

Tensile and yield strength properties, in short, appear to be insensitive to melting practice.

Toughness, however, as measured by resistance to impact loading, is a property known to be process-sensitive. In most cases, approximately a twofold improvement in notch impact strength in both the longitudinal and transverse direction is obtained by vacuum melting.

The fatigue properties of low-alloy high-strength steels have been improved considerably by the application of vacuum melting. A comparison of the fatigue strength of air-melted and vacuum-melted SAE 6150 (Fig. 1) shows that the vacuum-melted alloy is superior to the air-melted material in both the transverse and longitudinal directions. Similar trends, as shown in Fig. 2, are noted for air-and vacuum-arc-remelted Nitralloy.

At this time, there is only a limited amount of the data on vacuum-degassed alloys which can be used to compare the capabilities of this process with those of other vacuum-melting techniques. What data are reported in the literature, however, are limited to grades not normally vacuum-induction-melted or vacuum-arc-remelted. A number of investigators have reported that vacuum degassing has substantially reduced gas content and nonmetallic inclusions in the grades studied. As a result of reduced hydrogen, flaking in large sections is virtually eliminated. Test results on rotor forging grades used in power-generating equipment indicate that vacuum degassing improves toughness and tensile ductility, reduces the transition temperature, and, in general, gives similar property improvements obtained by other vacuum processes.

More recently, several Japanese investigators have reported improved impact properties, tensile properties, particularly transverse ductility (elongation and reduction of area) in vacuum degassed Ni-Cr-Mo and 1.6% Cr steels. The authors found a considerable improvement in the quality of the vacuum-treated steels studied over that of similar grades produced by air melting.

TOOL STEELS: Use of vacuum-melting processes in hot-work die steels was brought about by the need of the aircraft industry for an alloy having high strength and good toughness at service temperatures near 1000 F for airframe and missile applications.

One of the steels which showed considerable promise for aircraft applications was the H-11 type steel used for many years as a hot-work die steel. Typical tensile properties of air-melted and vacuum-arc-remelted Crucible 218 (H-11 type) are shown in Table 3. Data clearly indicate that vacuum arc remelting has little effect on tensile and yield strength properties of this grade. Elongation and reduction of area values in the longitudinal direction are virtually unaffected, although some improvement is obtained in the transverse direction.

The H-13 type hot-work die steel is probably the most widely used steel for aluminum and zinc die casting dies and for long service zinc die casting dies. Although by far the great majority of die casting dies are being made successfully from air-melted material, the use of vacuum-melting processes to obtain a cleaner steel free from internal defects in large sizes is drawing wide attention in the die casting industry. Some typical tensile properties of Crucible Nu-Die V (H-13) produced by air-melt and vacuum-arc-remelt practice are shown in Table 4.

Although the vacuum-arc-remelted material was heat treated to a higher hardness level, a significant improvement in ductility was noted over the air-melted material.

SUPERALLOYS: Higher performance materials vital to the safe operation of the jet engine have been achieved through the use of vacuum-melting processes. Until this time, service temperatures were limited to about 1250 F since materials operating at this temperature could be adequately produced by air melting. With the demand for materials to withstand higher and higher temperatures, new iron- and nickel-base alloys were developed which by necessity contained greater amounts of reactive elements such as Ti, Al, Zr, and B. As the control of these elements became increasingly more difficult even with the best available air-melt practice, the stage was set for the development of improved vacuum processes to produce these and other high quality alloys.

Vacuum melting has been observed to improve the fatigue properties of superalloys at elevated temperatures.

IRON-ALUMINUM ALLOYS: Iron-aluminum alloys have been studied extensively since 1933. Some of the properties that have created a continuing interest in this group of alloys are: excellent oxidation resistance, low density, good magnetic properties, and high electrical resistivity. As a result, they have been considered for applications as compressor blades and housings in jet engines, structural members in aircraft, electrical resistance heating elements, and many others.

Thermenol is a 16% aluminum ferritic alloy developed by the Naval Ordnance Laboratory which contains 3 to 4% molybdenum for improved elevated temperature strength. Recently, Crucible developed a high-strength age-hardenable austenitic Fe-Al-Mn-C alloy containing small additions of Ni, Mo, W, and V.

The elevated temperature properties of Thermenol compare favorably with Type 304 properties. Thermenol has a considerable advantage over Type 304 stainless due to its lower density and excellent oxidation resistance.

MAGNETIC MATERIALS: It is generally known that impurities have a marked effect on magnetic properties and, for this reason, vacuum-induction-melted alloys would be expected to be superior to air-melted alloys. Note that the vacuum-induction-melted alloy has the higher maximum permeability, lower coercive force and lower hysteresis loss than the Armco iron. These improvements are achieved by vacuum induction melting through the use of high-purity raw materials and consistently close chemistry control not attainable by the air melt process.

Although vacuum-induction-melted material will command a higher price, there are advantages to

Table 1

Nominal Compositions of Some Low-Alloy High-Strength Steels

Grade	C	Mn	Si	Cr	Ni	Mo	V	Application
UHS 260	0.35	1.25	2.00	1.25	—	0.35	0.20	High strength
4340	0.40	0.70	0.25	0.80	1.80	0.25	—	High strength
300-M	0.40	0.75	1.60	0.85	1.85	0.40	0.08	High strength
6150	0.50	0.80	0.25	1.00	—	—	0.20	Springs
9315	0.15	0.50	0.25	1.50	3.25	—	—	High hardenability gears
Nitralloy	0.40	0.50	0.30	1.50	—	0.30	—	Gears and shafts
52100	1.00	0.35	0.25	1.50	—	—	—	Bearings
D-6	0.47	0.75	0.25	1.00	0.50	1.05	0.08	High strength

Table 2

Typical Properties of SAE 4340 Made by Various Melting Processes

Melting Process	Test Direction	Hardness Rockwell C	0.2% Yield Strength, psi × 1000	Tensile Strength, psi × 1000	Elongation, %	Reduction in Area, %
Air Melting	Longitudinal	54	222	290	10	35
	Transverse	54	221	289	5	17
Vacuum Arc Remelting	Longitudinal	55	—	293	13	42
	Transverse	55	—	291	11	28
Vacuum Induction Melting	Longitudinal	54	215	285	12	41
	Transverse	54	222	287	10	40

Table 3

Typical Tensile Properties of Air-Melted and Vacuum-Arc-Remelted Crucible 218 (H-11)

Melting Process	Test Direction	0.2% Yield Strength, psi × 1000	Tensile Strength, psi × 1000	Elongation, %	Reduction in Area, %
Air Melting	Longitudinal	240	290	10	35
	Tranverse	235	285	5	10
Vacuum Arc Remelting	Longitudinal	245	295	10	35
	Transverse	240	295	10	35

Table 4

Typical Tensile Properties of Air-Melted and Vacuum-Arc-Remelted Nu-Die V (H-13)

Melting Process	Test Direction[1]	Hardness Rockwell C	0.2% Yield Strength, psi × 1000	Tensile Strength, psi × 1000	Elongation, %	Reduction in Area, %
Air Melting	Radial	52	208	264	1.2	3.9
	Tangential	52	210	266	1.2	4.1
Vacuum Arc Remelting	Radial	54	223	280	3.5	13.9
	Tangential	54	220	278	3.3	7.1

[1] Samples cut from pancake forgings.

vacuum-induction-melted alloys which will compensate many times over the increased costs. Greater reliability can be built into electrical components because of the greater uniformity in composition and magnetic characteristics. Weight savings through miniaturization of electrical components are made possible because of high permeability, low coercive force, and core losses associated with vacuum induction melted materials.

Conclusion

These examinations lead to the belief that the future automobile will use more vacuum-melted materials than its predecessor. As the automotive engineer learns the full capabilities of vacuum-melted materials — and as costs are decreased — wider usage of high-quality, high-performance alloys is likely to find a growing place in the automotive industry.

Bow thrusters—devices located in the forward part of a ship to give it bow control—are being used increasingly . . .

Based on paper by

Howard H. Scott
Bird-Johnson Co.

BOW THRUSTERS — submerged propeller-driven devices located in the forward part of the hull of a vessel to provide bow control — are being installed more and more in new vessels and also in existing ships of all kinds. Special-purpose vessels, such as missile trackers, oceanographers, and off-shore deep well drillers, need them to provide precise position keeping. But they are also being installed on more conventional vessels, such as buoy tenders, dredges, ferries, freighters, and even large ocean-going passenger liners.

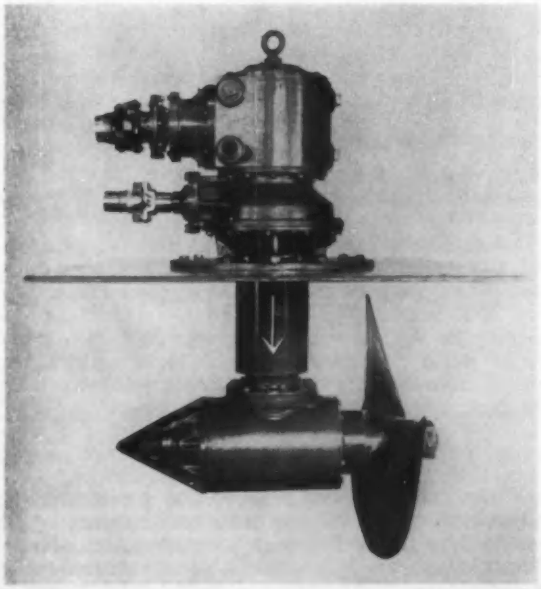


Fig. 1 — **Allguire marine drive** — a right-angle bow thruster used on riverboats to provide both steering and propulsion.

Some of these bow thrusters are designed only for steering, others can be used for both steering and propulsion. In any case, they greatly improve the maneuverability of a vessel, thereby increasing productivity, reducing hull and property damage, and improving the self-reliance of the vessel — just in case.

Fig. 1 illustrates a right-angle bow thruster that has been used on riverboats to provide both steering and propulsion.

Fig. 2 shows a fixed-pitch propeller installed in a short, transverse tunnel section, which can be raised or lowered to facilitate steering, whether the barge be loaded or light. Fig. 3 shows the deck machinery, which consists of a GM-6-110 diesel engine rated at 210 hp at 1800 rpm. It drives through an Allison reversing torque transmission and Johnson right-angle drive to a Murray & Tregurtha "Harbormaster" 54 × 40-in. propeller. The drive components can be raised or lowered hydraulically, and control of the whole unit may be local on the barge, or from the pilot house.

Fig. 4 shows a bow thruster developed for the Great Lakes dredge "Markham" by the U. S. Army Corps of Engineers, Avondale Shipyards, Inc., and the Link Belt Co. Two 75-hp variable-speed and reversible, electric motors drive through a chain drive to a fixed-pitch propeller. The unit is reported to develop 4000 lb of thrust when the 4-ft diameter propeller is rotating at 360 rpm.

Fig. 5 shows the basic construction of a bow thruster developed by the Karlstad Mechanical Works of Sweden. It consists of a tunnel section with tripod supports for both the drive end and control end of the controllable-pitch propeller. The components are fully erected and shoptested prior to shipment and are installed as an assembled unit within the hull of the vessel. The bow thruster tunnel may be welded permanently to the ship struc-

. . . to improve ship maneuverability

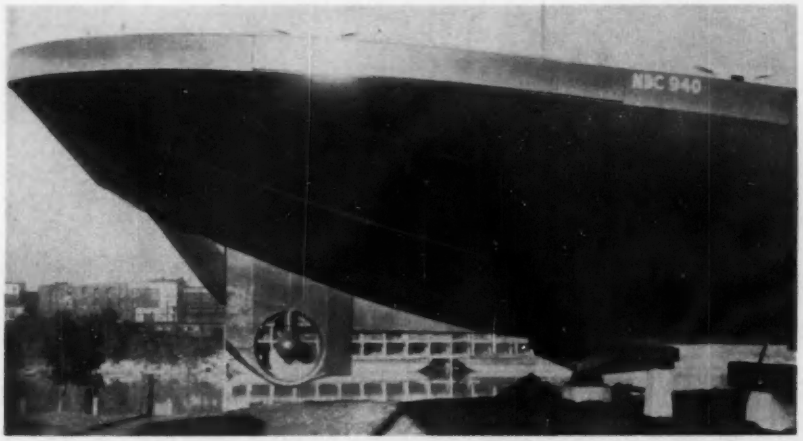


Fig. 2 — **Bow thruster and Ashland Oil Co. barge,** in the lowered position.

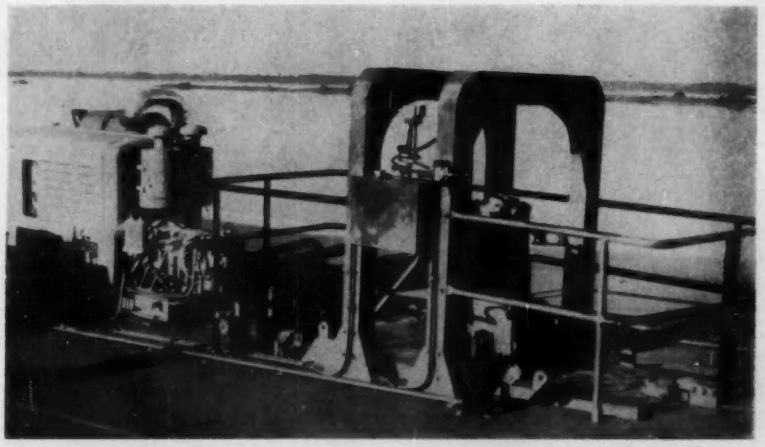


Fig. 3 — **Deck machinery** for bow thruster on Ashland Oil Co. barge.

Ship maneuverability

... continued

ture or made removable through bolted construction. In either case, damaged blades can easily be removed for repair and the right-angle drive, propeller hub, and controls can be withdrawn for inspection with the tunnel in place.

The unit is diesel driven, with the engine mounted adjacent to the tunnel — both of which are located just aft of the collision bulkhead in a lower hold space, which was formerly used for additional ballasting. Pilothouse controls include provision for starting and stopping the engine plus the pitch and speed control at two bridge wing stands as well as in the pilothouse. Overload control is included to adjust pitch automatically, thus preventing engine overloading. Preliminary tests indicate that about 4000 lb of thrust can be developed with 150 hp to the bow thruster.

To Order Paper No. 376A . . .
from which material for this article was drawn, see p. 6.

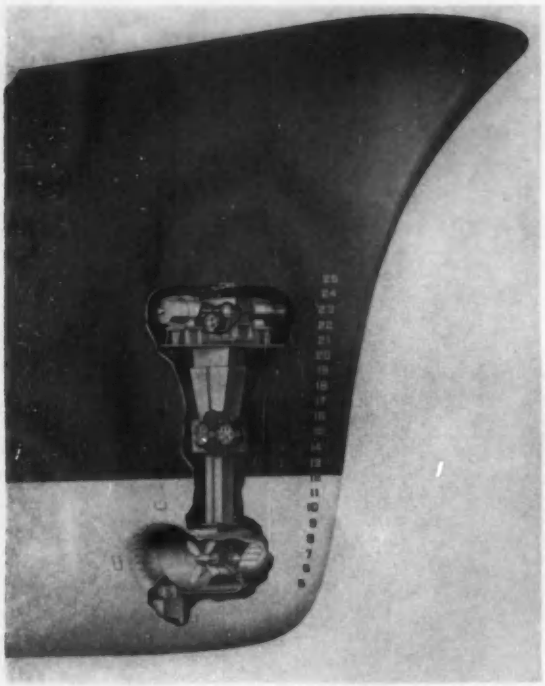


Fig. 4 — **Bow thruster on Corps of Engineers' dredge "Markham,"** showing Link Belt drive.

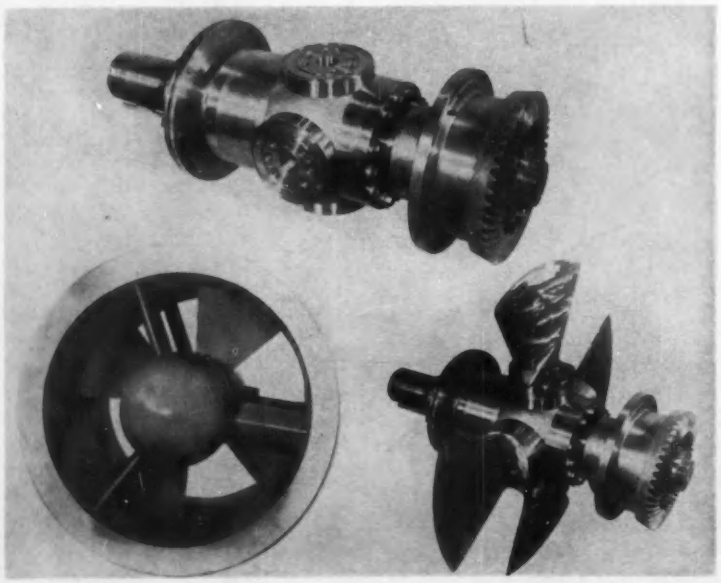


Fig. 5 — **Components of bow thruster** developed by Karlstad Mechanical Works of Sweden.

from

TEXAS SECTION

automotive air conditioning forum

Technical progress is being recorded in all phases of

automotive air conditioning

Specific advances are detailed in SAE's new SP-185 from which material in this article was drawn.

DESIGNERS are continuing to add to their knowledge of how to make automobile air conditioning more satisfactory — both in performance and cost. The major problems requiring study still pertain chiefly to conditions when engines are at idle or cars are operating at very low speeds. But much progress has been made in the last 36 months on engine cooling, V-belt constructions, compressors, design of clutches used to pick up compressors, and on thermostatic expansion valves — which are common to all automobile air conditioning systems. Control systems are being debated and improved also, and thermoelectric cooling for automobiles is being studied.

Ideas and data on all of these phases of automotive air conditioning have been exchanged recently among SAE engineers.

These experts emphasize the direct connection between condensing pressures in automotive air conditioning and the automobile cooling system under idling or less-than-10-mph operation. Since the condenser must be located forward of the radiator . . . and since heat removed from the car interior is rejected through the radiator, the cooling system performance is inevitably affected. A whole list of things, in fact, affect both the cooling system *and* the air conditioning unit . . . such as engine rpm; the forward speed of the car as it affects condenser and radiator ram air; speed and direction of the wind; temperature and atmospheric pressure; relative humidity; number of passengers; size of passenger compartment; position and intensity of the sun; variations in sunlight and shade; and color of car, tinted glass, and use of sun visors.

engine fan is important

The engine fan is depended on to draw air through both the condenser and radiator at slow speeds and when the car is stationary, Edd Huff of John E. Mitchell Co. points out in the new SAE publication (SP-185), titled "Auto Air Conditioning Forum." The heat removed from the car interior must be rejected through the condenser, he says, and goes on to point out that:

Actually this condenser heat amounts to only 5000 or 6000 Btu per hr at idling speeds. The engine cooling fan moves approximately 450 cfm across the radiator, again at idling speeds. This means that at 90 F ambient, an approximate increase of air entering the radiator of 14 F would result. Thus, there would be an air temperature entering the radiator of 104 F.

Unfortunately, this again does not tell the whole story. The longer the automobile is operated at idling or very slow speeds, under 10–15 mph, the higher the cooling system temperature and to a lesser degree the condenser temperature. This, of course, represents a system liability. With this condition comes higher discharge and suction temperatures, due to reduced compressor capacity. Thus there is a vicious cycle in effect: rapidly increasing engine cooling temperatures and a slower but nevertheless

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TEXAS SECTION

automotive air conditioning forum

steady increase in condensing or head pressures. Increased coolant temperatures and refrigerant pressures cause high compressor torque, with possible engine stoppage as well as a reduction in compressor drive belt life through belt slippage. If continued for 20–30 min, boiling of the engine coolant will very likely result and some of this coolant will be released by the radiator pressure cap and discharged through the radiator overflow tube.

As soon as the car's forward speed is resumed, ram air in addition to that drawn in by the engine fan, causes both the condensing and cooling system temperatures to decrease.

Among the other causes of higher than normal head pressures in automotive air conditioning equipment, Huff cites:

- Overcharge of refrigerant or air in the system.
- Clogging of the condenser with dirt, insects, leaves, or other foreign material.
- An expansion needle valve stuck open or a loose thermo bulb clamp (rare).

Recent experiments noted by Moline's P. J. Kohler, indicate that efforts to insure air flow to the radiator and condenser at low car speeds are "not only in the direction of positive correction, but also may be the most economical means to achieve lower heat pressures and lower radiator water temperatures."

To attain adequate cooling, the experts agree, use of a more severe fan is necessary when the car has an air conditioning system. But this more severe fan brings with it a high noise level and greatly increased canned horsepower requirements at the higher engine speeds. To correct these adverse effects, Eaton Mfg. Co. developed tempatrol and terpatrol clutches — the latter of which permits a higher pulley ratio to improve the idle cooler.

If the more severe fan is used without the tempatrol clutch Eaton's Lou Selin explains, the noise would be intolerable as the engine speed increased. But with tempatrol clutch, the fan remains at idle speed even when the engine rpm increases. If engine cooling is required, the clutch engages, and the fan speeds up to a predetermined limit. . . . This limit is still below the objectionable noise level, yet provides adequate cooling at higher road speeds.

clutch performance rated

Development of specific acceptance standards for magnetic clutches on automotive refrigerant compressors is said to be going far to insure that such clutches will unfailingly "pick up" the compressor at two optimum conditions:

1. Engine idle speed; low voltage due to low idle speed, high head pressure.
2. Maximum engine speed, normal voltage, reduced head pressures.

When a magnetic clutch is used in connection with a by-pass system, the number of cycles it experiences is roughly one-fourth of a number needed for a system in which the clutch itself is thermostatically cycled. The "acceptance standard" which Warner Electric Brake & Clutch Co. uses for clutches with these applications is shown in Table 1 . . . while Table 2 shows the "acceptance standards" for a thermostatically clutch-cycled system, the requirements of which are quite different.

compressor progress

Compressor producers are predicting continued improvement, but foresee no major changes in their products in the near future — as applied to automotive air conditioning. E. R. Boynton of Tecumseh Products, for example, thinks the most likely course of progress in the next few years will be "in further refinement of fixed displacement compressors driven directly from the automobile engine, but more closely married to the control portion of the air conditioning system." He does, however, look for lower prices, some further decrease in size of compressors, further improvement in quality, and closer integration of compressor with the air conditioning control system.

thermoelectric systems studied

Thermoelectric cooling systems for automobiles are being studied currently, and much authoritative factual data have been developed. The characteristics of a thermoelectric cooler developed by Texas Instruments, Inc., is shown in Table 3. The electrical power that must be supplied to the thermoelectric cooler is 22,800 Btu/hr. The coefficient of performance is dependent on the "figure of merit" of the material and the operating temperature of the cooler. (The "figure of merit" of a material is an index of its quality as a thermoelectric material.)

The maximum coefficient of performance is 0.64 with a present thermocouple "figure of merit" of 2.7×10^{-3} deg K^{-1}. The cost of the thermoelectric material for the analysis in Table 3 would be about $19,000 based on present material cost of $500 per lb. . . . Using a 24-v source, 400 thermocouples and a current of 281 amps would be required. With a 1100-v source, 18,400 thermocouples and a current of 6 amps would be needed.

Summarizing the competitive ability of thermoelectric cooling for use in general air conditioning systems at present, Texas Instruments' Raymond Marlow says in effect: "They aren't competitive with

conventional systems." But he adds: "For specialty items that dissipate below 400 Btu/hr, thermoelectric cooling is competitive with conventional mechanical systems and, in some instances, there is apparently no other cooling technique that can equal thermoelectric capabilities."

control systems

The compact size of automotive air conditioning units and the variable speed of the compressor make necessary controls which will do more than just control the refrigerant to the coil. In addition to the thermostatic expansion valve, car air conditioner controls had best be able to:

- Prevent the coil from icing up under some operating conditions.
- Modulate the capacity of the system.
- Pull down the evaporator coil pressure quickly on initial start-up of the unit.
- Deal with the high head pressures sometimes met when a car idles or moves slowly through traffic.

To help accomplish all this, future designs will probably involve some sort of power take-off from the engine, according to C. D. Orth, Controls Co. of America. This power take-off, Orth feels, either will hold the compressor speed constant or make it variable with respect to engine speed. "There are still problems to be overcome in design of such a unit," Orth admits, but urges that if it can be perfected — at an acceptable cost — "all of the control problems relating to automobile air conditioning will be greatly simplified."

T. E. Noakes, American Standard Controls, seems

Table 1 — Acceptance Standard for Clutch with By-Pass System

Applications	rpm	Head Pressure, psi	Suction Pressure, psi
15,000	500	395–405	50–60
15,000	4,500	170–180	13–17

Table 2 — Acceptance Standard for Thermostatically Clutch-Cycled System

Applications	rpm	Head Pressure, psi	Suction Pressure, psi
24,000	500	395–405	50–60
24,000	1,500	215–275	16–20
24,000	2,500	200–210	16–20
24,000	3,500	185–195	13–17
24,000	4,500	170–180	13–17

Table 3 — Characteristics of Thermoelements for Maximum Coefficient of Performance

Heat Removed, Q = 4,300 w = 14,600 Btu/hr
Input Power, P = 6,750 w = 22,800 Btu/hr
Coefficient of Performance, E = 0.64
Length of Material, L = 0.2 in.
Cost = $19,000

Thermocouple Assembly	No. per Assembly		
	400	5,640	18,400
Voltage, Volts	24	338	1,100
Current, Amps	281	20	6
Thermocouple Dia., In.	1.05	0.27	0.16

Table 4 — Performance Chart

25 mph — Cool Down
110–78 deg
Full Solar Load — 25 mph Wind

	Valiant 4-blade fan				Valiant 6-blade fan				DeSoto 7-blade fan			
Time, min	5	15	30	60	5	15	30	60	5	15	30	60
Car Interior Temperature, F	83	75	72	70	83	75	71	68	85	80	76	73
Discharge Pressure, psi	235	225	226	226	230	220	220	220	225	218	215	210
Radiator Temperature, F	185	188	200	204	183	185	186	186	182	190	190	190

Idle Test — 110–78 deg
No. wind — 600 rpm

Time, min	5	15			5	15			5	15		
Interior Temperature, F	75	83			71	75			73	77		
Discharge Pressure, psi	315	375			270	305			275	313		
Radiator Temperature, F	230	250			202	217			215	243		

City Traffic Test 110–78 deg
No. wind — idle to 30 mph

Time,min					5	10	15	20	5	10	15	20
Discharge Pressure, psi					305	328	333	350	316	327	335	357
Radiator Temperature, F					200	212	222	228	212	228	237	243

from

TEXAS SECTION

automotive air conditioning forum

to be thinking in the same direction when he speculates: "It is possible that the problem of capacity control will be solved within the compressor . . . and "it may someday have a constant speed system."

V-belt construction is seen by some engineers as having an important bearing on car air conditioning design and performance. Robert E. Stetson, Gates Rubber Co., in fact, sees the V-belt as "the heartbeat of the automotive air conditioning system." Loss of power to drive the freon compressor, he points out, makes the whole system useless. While steel cable V-belts are the most widely used, Stetson believes that "textile cord V-belts can do the job," too.

air conditioning the compacts

Car engineers seem agreed that air conditioning systems should be made to circulate air so that both front and rear seat passengers are comfortable — without a direct blast of air being concentrated on any area. None dispute American Motors' R. F. Jenson when he says: "Cold air does not mean comfort in a passenger car unles it is properly distributed."

And much interesting, specific data about air conditioning performance in "compact" and "standard" cars has been revealed lately by Chrysler Airtemp's R. W. Gilmer. Writing in this SP-185, Gilmer presents an air conditioning performance chart comparing Valiant and De Soto, as shown in Table 4.

"During the 25 mph cooldown," he says, referring to Table 4, "car interior temperature, discharge pressure and radiator temperature are approximately the same for a Valiant (with either a 4- or 6-blade fan) and the DeSoto.

"The difference between the 4- and the 6-blade fans is increased at idle. At 15 min after using the 6-blade fan, discharge pressure is reduced 70 psi . . . and radiator temperature is lowered 33 F. There is no air flow over the car during the city traffic test. This causes higher head pressures, but correlates closer to actual city traffic conditions. At 15 min, head pressure is 28 psi higher than shown at idle. Discharge pressure and radiator performance are comparable to the large car.

"A Valiant and a Chrysler New Yorker compare within 1 to 3 F during a 25 mph, 110 F cool down test and idle test. Results show that the Valiant with the smaller capacity compressor, standard evaporator, 17-in., 6-blade fan and fan shroud, high superheat, low maximum operating pressure expansion valve has performance comparable to the conventional cars."

To Order SP-185 . . .
from which material for this article was drawn, see p. 6.

Little divergence of opinion appears among fleet operators about how to select . . .

The Right

THERE's a wide area of agreement among motor vehicle fleet operators on how to go about selecting vehicles for their fleets . . . and on the factors most important in the selection process. Transportation engineers emphasize establishment of job requirements for the vehicle, for example, whether they are selecting for a door-to-door delivery fleet, an over-the-road truck fleet, a passenger car fleet; or a fleet of specially vehicles for public utility service.

Typical representatives of each fleet-type state their methods for selecting the right vehicle for the right job in slightly different phraseology in the recently issued Vol. 2 of the new SAE TECHNICAL PROGRESS SERIES. But a considerable unanimity approach is revealed from analysis of the four separate studies which comprise this T & M Activity Committee-sponsored volume.

Capital investment, operating costs, and "standardization," for instance, are commonly indicated as factors of relatively equal importance, along with the already-mentioned clarification of the vehicle's job requirement. Mentioned also in more than one instance are factors such as original cost, extra equipment, reliability, maintenance availability, and fuel economy.

National Dairy Products, for example, goes about selecting vehicles for its door-to-door delivery fleet through what amounts to a 9-step process. The first step is to review the route requirements, and determine the job the vehicle is to do. This establishes facts about mileage, terrain, road and traffic conditions.

Then the performance of NDP's existing trucks are analyzed, and used as a guide to selecting the new ones. Next, every opportunity for improved savings through better standardization of the fleet is looked for. Then follow the steps of investigating available equipment, getting quotations from manufacturers, receiving and evaluating quotations, placing the order, following up on the work in process and, finally,

Vehicle for the Job

But each type of service brings emphasis on different factors as of major or minor importance

placing the new vehicle in service.

The most important considerations in selecting passenger cars for the Armour & Co. fleet are: original cost, extra equipment, area of operation, prestige factor, life expectancy, resale value, maintenance, Armour advertising requirements, and Armour company policy.

Commenting on the "advertising requirements" item, Armour's Harry O. Mathews, general manager, transportation and distribution, says:

"In some types of business it is not advisable to carry any advertising on the vehicles. In other cases, there is some value — although it is hard to determine how much. . . . Advertising agencies differ about the value of passenger car advertising which includes special paint jobs, permanent insignia, and other changes. . . . Such 'advertising' has little to do with the selection of the vehicle, except when special paint jobs add to the original cost, and have a deterrent effect on sales. . . . Armour has found it advisable to select a standard manufacturer's color that is the same in any make of vehicle. To this color, we add the car number — and in some cases a simple decalcomania that can be changed easily when it fades; or easily removed without leaving any mark on the car when it is sold."

Each type of service — and each individual company within each of the types — has special requirements in addition to those which are common to all fleet selection processes. Nowhere is the element of special requirements better illustrated than in public utility service fleets. As a result, the factors emphasized in selection of vehicles for such fleets include such items as: simplicity of design, ability to withstand rough, off-highway service; clean bottoms for the vehicles; and suitable mounting of accessories.

In a big public utility service fleet like that of the Tennessee Valley Authority, for example, unusual stress is laid on suitable power assists . . . and on plenty of available power from the powerplant itself. So important is this last factor to such fleets that TVA's Charles C. Hudson is found urging:

"Let's have a horsepower race in trucks!

"The proper gear selection," he says, "presupposes available engine sizes that some manufacturers do not offer. Why is it that manufacturers will offer a 348-cu in. engine in the cheapest line of sedans, with a 4000-lb gvw, but only a 238-cu in. powerplant in a 22,000-lb gvw truck?

"If weight conditions indicate a need for the 348-cu in. engine, TVA must buy a 23,000-lb gvw truck with a different transmission and rear axle. Yet, on our job, we have changed from 270 to 360 cu in., with only clutch change, and have improved the life of the transmissions, drive lines, and rear axles. . . . We have changed from 450 to 501 cu in. and improved gas mileage by 15%. . . . The horsepower race, like automatic transmissions, should have come to trucks first — not to sedans."

The safety factor — as might be expected — seems to be stressed most strongly in vehicle selection by over-the-road operators. J. B. Boynton of F. J. Egner & Son, for example, says:

"Although all modern vehicles must be bought with driver comfort and ease of operation in mind, some vehicles are operating which leave something to be desired as regards safe operation. With some wheelbases and fifth-wheel settings, the load distribution and steering control is such that only by faith can the driver bring the vehicle out of a tight situation under minimum traction conditions with the steering axle in the lead position rather than in some other position which offers no control."

In general, fleet operators are found aiming at somewhat the same objective, regardless of the type of vehicle or service with which they are concerned, namely — the ability to deliver maximum volume or service at minimum cost.

To Order TPS-2 . . .
from which material for this article was drawn, see p. 6.

Heavy trucks taking to

Power assist needed to offset heavier front

Based on paper by

T. I. Monroe

Ross Gear & Tool Co., Inc.

THE effort required to steer the modern heavy truck has made power steering more popular as optional equipment and is leading to general acceptance of it as standard equipment. The centerpoint axle does reduce steering effort for vehicles in motion, but power steering works even better and there is no advantage in combining the two.

Static or nonrolling conditions

A theoretical relationship exists which gives the handwheel efforts as a function of the summation of kingpin torques divided by the overall steering ratio and the overall mechanical efficiency. The kingpin torques (summation of left and right handwheel moments) consist of two basic components. First and most important is the scuffing-rolling rotation of the tire footprint about the kingpin intersection at the ground. Second is the effect of the inclined kingpin to lift the load as the wheel is turned from center. Empirical studies show steering torque to be a function of the tire loading, friction coefficient, tire offset from kingpin intersection, kingpin inclination, and tire footprint size. All are directly or indirectly affected by front-axle loading. For average conditions, torques increase approximately with the load.

Increasing the wheel turning angle also has a pronounced effect upon steering torques. For the typical left-hand-steer, fore-and-aft drag link type installation, the relative change in steering effort is as shown in Fig. 1. Obviously, axles which provide wheel cuts of 42–45 deg will result in an even greater change in kingpin torque.

Importance of mechanical efficiency

While overall mechanical efficiency is very important to minimizing handwheel efforts, most heavy-duty type steering gears fall in the 72–82% efficiency range and this seems to be the practical maximum. Recovery force and shock load transmission become excessive at efficiencies higher than 80%. Linkage losses are modest and have very slight effect on efficiency.

Overall steering ratio (product of gear ratio and linkage ratio) is of equal importance to efficiency. To counter heavier axle loadings, steering gear designers have pushed ratios higher and higher.

Improvements in mechanical advantage and efficiency have greatly moderated the effect of heavier front-end loading, yet even if physical limitations did not restrict further increase of ratios, the practicability of steering with excessive wheel turns would do so. This fact, coupled with the desirability of obtaining adequate response at road speeds, is responsible for making variable ratio gears popular.

Why of centerpoint axle

The centerpoint axle was developed in an effort to reduce kingpin torques and effect a proportional reduction in steering effort. It changes two important features affecting steering torques: (1) the kingpin offset is reduced to between 20–50% of the standard axle offset and (2) kingpin inclination is reduced from the usual 4–8 deg to near zero.

The reduction of kingpin offset increases the scuffing-rolling friction effect which results in as much as 16% greater torque requirement than that of the standard medium offset axle. This is shown in Fig. 2. At the same time, elimination of the kingpin inclination decreases kingpin torques significantly. Inclination causes the chassis to be lifted as the wheel turns from center, and this lift contributes as much as 12% of the total kingpin torque for axles with considerable k.p. angle. The effect of kingpin inclination is plotted for four angles in Fig. 3.

As a result of these two opposing effects, the centerpoint axle may yield little, if any, net benefit to

power steering

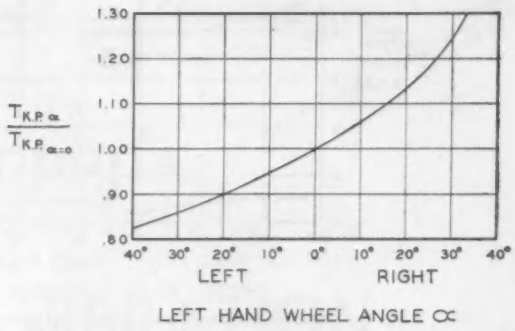


Fig. 1 — Relative change in steering torque caused by increase in wheel turning angle.

end axle loadings and wider steering angles.

static steering efforts in the straight ahead position. However, it should show a small advantage near the full turn position. In making quantitative comparisons, it is important that other factors, such as overall ratio, be considered accurately in order to avoid misloading results.

If the static efforts are too high on a vehicle which has been engineered to include the proper steering gear as well as reasonably good linkage arrangement, then only power steering will improve the situation appreciably.

Where power steering comes in

While it is not practical to rule categorically on the axle loadings which require power steering, there is popular acceptance that power steering should be considered standard equipment for off-highway vehicles with front-axle loads of 9000 lb or more. It may even be needed on city delivery vehicles with 9000-lb front loading if there is a lot of low speed work and much static turning. It is a boon for on-highway vehicles with GFEW of 11,000 lb and a necessity when loading rises to 15,000 lb and over.

Fig. 4 compares maximum handwheel torque for centerpoint axle, conventional axle, and power steering. In this instance the vehicle has an overall ratio (center) of 31.4/1, 11,000-lb front end weight, 75% efficiency, and 11.00/20 tires. Drag-link geometry compensates for the torque variations caused by the Ackerman linkage.

Moving or rolling conditions

The parameters affecting torque under rolling conditions are: front-end weight, velocity, turning radius, wheel angle, road surface friction, kingpin inclination, its offset and caster. Most of these are shown in Fig. 5.

Increasing velocity has a two fold effect, (1) greater centrifugal force under turning conditions, (2) variation of the tire-print, drag-center location. Steering torque increases proportionately with

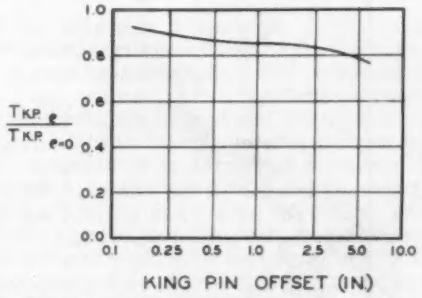


Fig. 2 — Effect of kingpin offset on static torque. Vertical axis is the ratio of kingpin torque for axles with offset to axles without offset. Horizontal axis is the kingpin offset relative to the centerline of the tire at the ground. The effects of kingpin inclination and friction are not included.

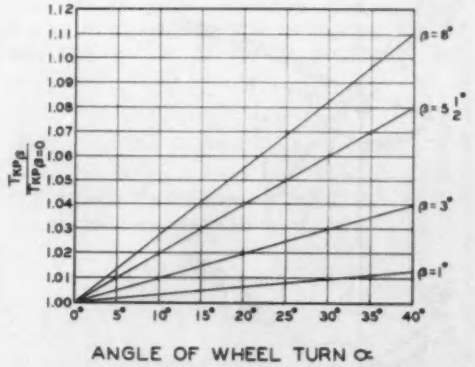


Fig. 3 — Effect of kingpin inclination on steering torque, plotted for four angles. The vertical axis is the ratio of kingpin torques for axles with inclination to axles without inclination. The effect of various inclinations is plotted with respect to angle of turn. All other effects, including those of caster and camber, are neglected.

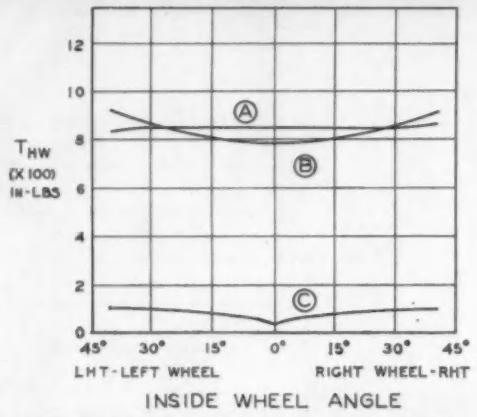


Fig. 4 — Comparison of handwheel torque required for static steer with centerpoint axle (A), conventional axle (B), and conventional axle with power steering (C), shows great advantage of power steering under static conditions.

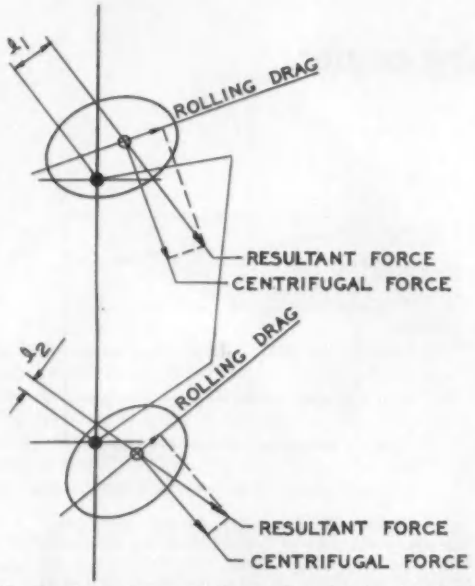


Fig. 5 — Force diagram for the tire footprints in a left-hand turn with a conventional axle.

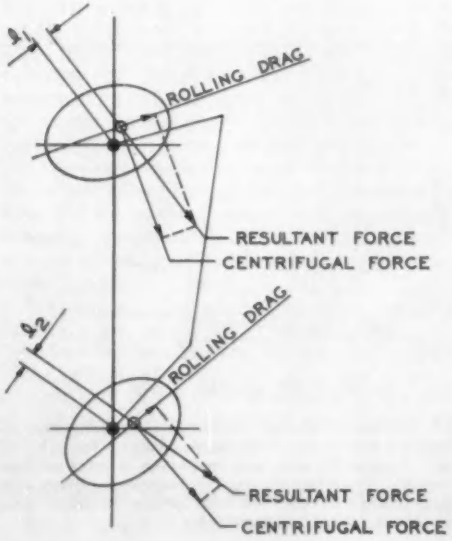


Fig. 6 — Force diagram for the tire footprints in a left-hand turn with a centerpoint axle. Compare "I" with its counterpart in Fig. 5.

rolling resistance which is a function of tire loading. Angle of steer, increased velocity, and sharpness of turn make up the centrifugal force component, further magnifying the torque requirement.

The effect of the vertical kingpin and reduced offset of the centerpoint axle is considerably greater for rolling conditions than for static ones because the lower torque level enhances the relative improvement due to the vertical kingpin, and because the offset decrease results in a large reduction in the moments due to drag center location (Fig. 6).

Power steering helps again

Steering torques under rolling conditions are shown in Fig. 7. In this instance the conditions are: GFEW 9200 lb, tires 11:00/22, velocity 10 mph, overall ratio 31.4/1, efficiency 75%. Note that the reduction in steering torque effected by power steering is not as drastic under rolling conditions as under static ones.

Having seen the improvement in steering effort which can be had from using the centerpoint axle, and the further improvement possible with power steering, truck operators have asked why the two should not be combined. The answer is this. With the proper offset and castor arrangement, a modified centerpoint axle could result in acceptable handling characteristics with power steering. Further, it is quite possible that the reduced working load would enhance the life of power steering components and decrease service requirements.

The combination of a variable ratio steering gear and a power assist unit does make it easier for the truck driver. This type of gear uses a high center position ratio (20–25/1) for adequate road speed control, but drops the ratio in the ends of travel to 10 or 15/1. The result is a pronounced decrease in lock-to-lock wheel turns without sacrificing high speed control.

To Order Paper No. 368A . . .
from which material for this article was drawn, see p. 6.

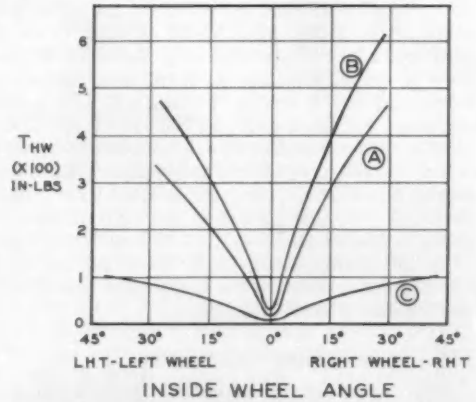


Fig. 7 — Comparison of handwheel torque required for rolling steer at 10 mph with centerpoint axle (A), conventional axle (B), and conventional axle with power steering (C).

Flexible bearing supports help stop VIBRATION . . . in gas turbine shafts

Based on paper by

Glenn Hamburg and Jon Parkinson

Continental Aviation and Engineering Corp.

IN A HIGH SPEED rotating system, critical speeds can be placed outside the operating range by using flexible bearing supports. Forces transmitted to the stationary structure can be reduced at the same time.

Rotor unbalance is the principal source of mechanical vibration in the gas turbine engine. It may excite one or more critical speeds of the rotor itself and/or induce resonance in any combination of structural elements that may be tuned to the running frequency of the rotor. Through the proper combination of rotor and supporting structure compliances, the effects of unbalance and critical speeds are minimized.

The natural modes of a rotating shaft are illustrated in Fig. 1. As the spring rate of the bearing support is reduced from infinitely rigid to a finite value, deflections occur at the supports and modal shape changes. A decrease in resonant frequency accompanies this effect. When the spring rate approaches zero in the bearing support structure, the first and second natural modes degenerate until no deflection occurs in the shaft itself. The first and second critical speeds then become zero. The third mode degenerates to the shape of a completely unsupported shaft vibrating at its first critical speed.

The effects of bearing support flexibility on the first three critical speeds are shown in Fig. 2. A much greater operating range, free from resonant frequencies, is indicated for operation above the first and second critical speed than that available below the first. Extremely rigid bearing supports would be required below the first critical speed if all criticals were to be avoided. This condition is hard to achieve in a lightweight high speed gas turbine engine.

The resonant frequencies of the system can be controlled by regulating the spring rate of the bearing support structure. The required spring rates can be obtained through a flexible bearing retainer. Such a retainer is used on Continental's 217-5 turboshaft engine. It consists of a flanged cylinder having a series of longitudinal stringers, Fig. 3. The stringer dimensions determine the radial spring rate of the bearing cage, with maximum deflection limited by an oil fed snubber surface. Compliance of the structure is negligible compared to the relatively low spring rate of the cages, and the critical speeds can be controlled quite accurately.

Design values of bearing support flexibility are found from a series of curves covering the entire spectrum of possible critical speeds over the engine's operating range, Fig. 4. The curves are calculated by a digital computer programmed to determine the speeds which will fulfill the boundary conditions and satisfy the differential equation of motion of a balanced flexible shaft with variable cross-section whirling at a critical speed. The boundary conditions contain the values of spring constants for

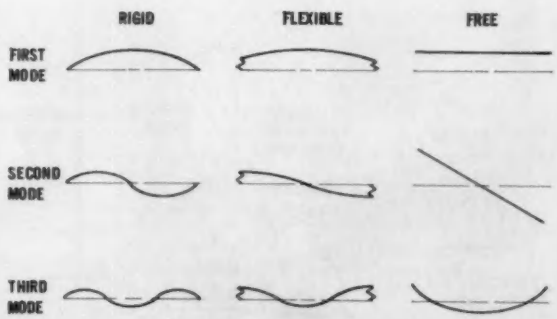


Fig. 1 — Natural modes of a rotating shaft for various degrees of bearing support stiffness.

which the particular critical speed is being determined.

The effectiveness of the spring cage in reducing vibration has been demonstrated on the Model 217-5 turboshaft engine. In one test the flexibility of the rear bearing cage was reduced by eliminating the deflection clearance. In spite of close balance of the rotor, vibrational levels increased by factors of 10–20.

Unbalance and transmissibility

To prevent vibrations in the main structure it is more expedient to remove the source than to alter the structure. Several unanticipated combinations of structural elements might exist that can be excited in the operating range of the engine. Eliminating these resonances could prove difficult.

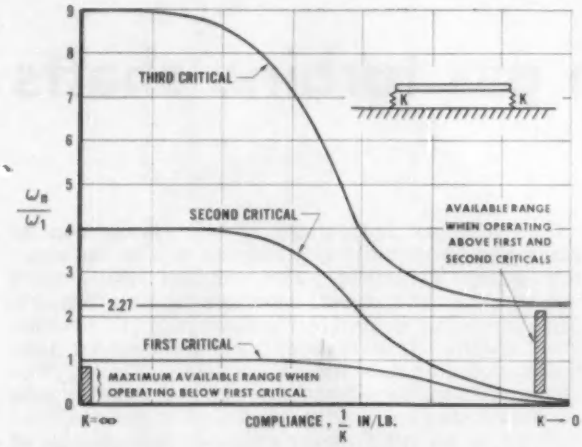


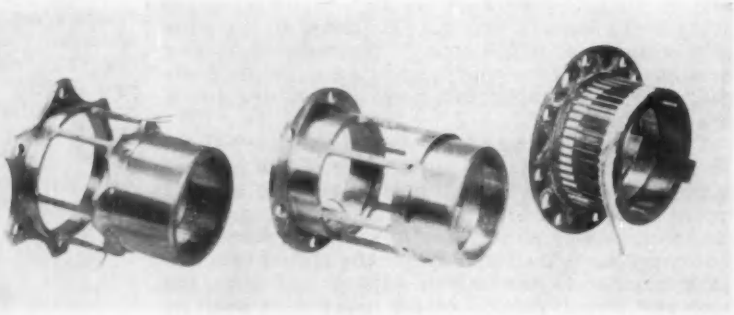
Fig. 2 — Effect of bearing support stiffness on resonant frequency. ω_n is the natural flexural frequency of the nth mode and ω_1 is the running speed.

Fortunately, isolation of the rotor from the engine framework is accomplished through the use of the soft rotor suspension spring system. This system allows the rotor to spin about its principal axis above the first two critical speeds with negligible transmission of force to the main stator.

This behavior may be explained by the single degree of freedom system shown in Fig. 5. The system consists of a thin disc rotating in the middle of an elastic shaft having no mass, with no damping. The centrifugal force caused by the unbalancing eccentricity, "e," tends to bow out the shaft (Fig. 5B). Deflection increases with speed up to the critical speed, where it theoretically becomes infinite. As the shaft passes through this speed, the heavy side of the rotor suddenly rotates 180 deg causing the disc c.g. to take a position between the disc centerline and the undeflected bearing centerline (Fig. 5C). With further increases in speed, the c.g. approaches the geometric center until, at several multiples of the resonant speed, the disc whirls practically about its mass center. At this point the only force transmitted to the foundation is equal to the product of the deflection of the shaft center by the spring rate of the shaft.

The amplitude of the disc center with respect to a given eccentricity is plotted in Fig. 5 against the ratio of driving speed to natural frequency. The behavior of the shaft is exactly the same with radially symmetric flexibility in the bearings except that the critical speed, which varies with the square root of the spring constant, is lowered.

If the flexible shaft is replaced by a rigid, but spring mounted, shaft with a disc at midspan as before, and viscous damping (corresponding to the oil fed snubbing surfaces) in parallel across each spring, the amplitude ratio curves appear as in Fig. 6. These curves are the same as in Fig. 5 except damping is now included. For larger values of the damping factor "C," the amplitudes fall off consid-



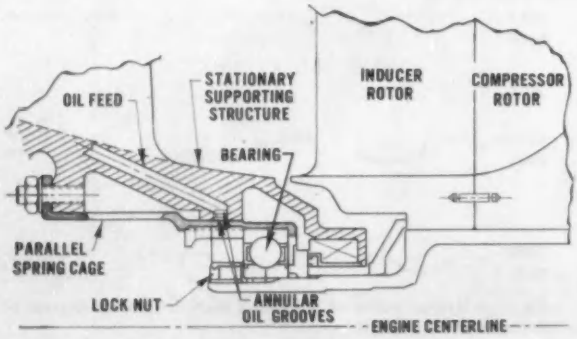


Fig. 3 — Flexible bearing cages (top), and a typical spring cage rotor suspension system.

erably with increasing speed. Thus, it appears that rotor excursion can be restrained by damping. But the main problem lies not so much in limiting the rotor deflection, but in isolating the unbalance forces from the framework. Damping can increase transmissibility.

The transmissibility ratio is the vector sum of the forces transmitted to the foundation through the spring and dashpot, divided by the centrifugal force of the static eccentricity at a speed equal to the natural frequency. Fig. 7 is a plot of this ratio as a function of speed for various degrees of viscous damping. The detrimental effects of damping is evident. Since transmissibility rises with speed for all degrees of damping, damping must be limited to the minimum value needed to run through resonance without excessive pounding.

The twin-spool gas turbine introduces the problem of external excitation of a rotating shaft at a different frequency than that at which the shaft rotates. The interaction between the two rotating systems can occur via wave propagation which can take the following paths. It can occur through the stationary structure from the support bearing of one system to the support bearing of the second system, or directly as a displacement function across a differential speed bearing. The importance of the excitation depends upon the relative mass or inertia of the individuals systems and their vibrational characteristics.

Tests conducted to explore these effects showed the following:

1. If the frequency of the displacement function is at, or close to, any particular critical speed of the shaft, that particular mode is excited independently of the rotational speed of the shaft.

2. If the displacement function frequency is close to a shaft critical speed, very high shaft amplitudes are created if the function acts at a node point.

3. The rotating force vector or displacement of both support bearings can be reduced to zero for any single critical speed range by a single correction weight at any axial location except a node section. It can be reduced to zero for a speed range in which two critical speeds occur, by applying corrections weights in any two axial locations. Again, the chosen locations must not contain node points.

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from which material for this article was drawn, see p. 6.

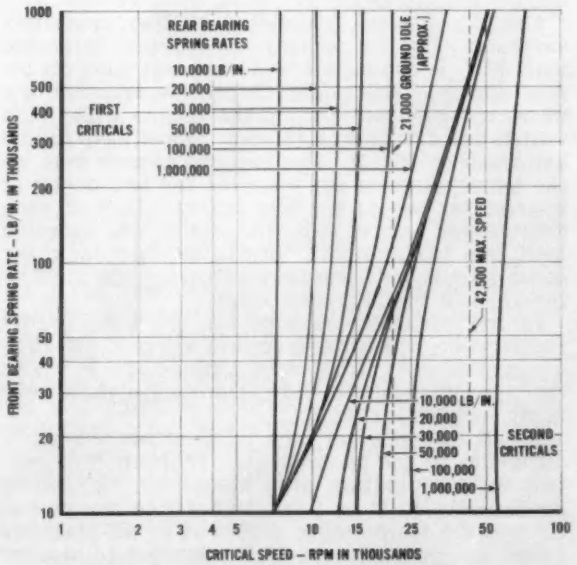


Fig. 4 — Critical speeds versus front bearing spring rate for various values of rear bearing spring rate.

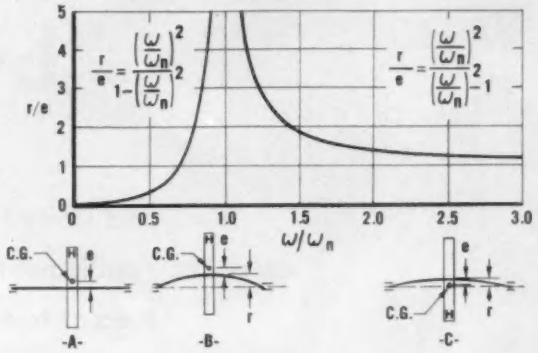


Fig. 5 — Amplitude ratio versus speed ratio for a whirling disc with no damping.

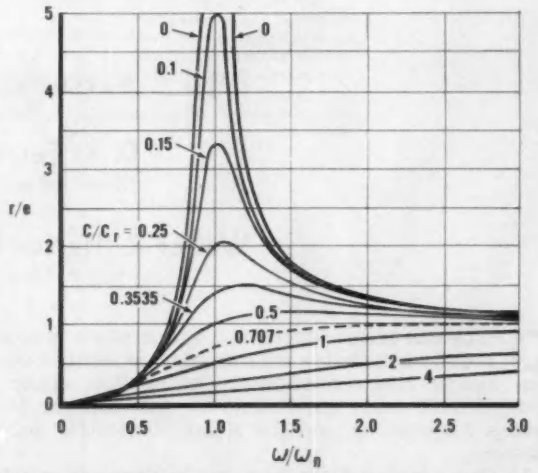


Fig. 6 — Amplitude ratio versus speed ratio for various amounts of viscous damping with an inertial driving force.

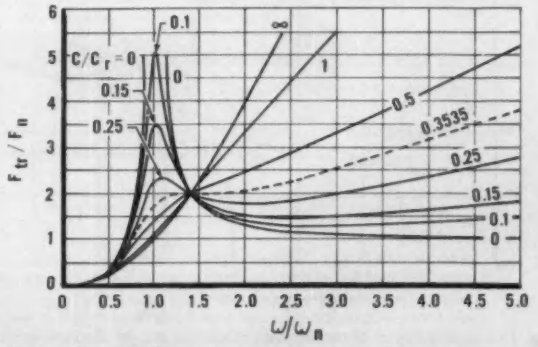


Fig. 7 — Transmissibility ratio versus speed ratio for various amounts of viscous damping with an inertial driving force.

Engine wear reduced by air flow control

For years United Parcel Service has specified radiator shutters on all their equipment . . . to have June in January under the hood. Recent tests show the benefits of such a cooling system.

Based on papers by

Peter P. Kazlauskas
Armour Research Foundation

D. R. Ferris
Kysor Heating Co.

and

Walter R. Herfurth
United Parcel Service

OPTIMUM engine operating temperature is more readily attainable with an air flow control system aiding the conventional water flow control. Independent tests conducted by the Armour Research Foundation and the Kysor Heater Co. point this out.

In the Armour tests two trucks were driven in Chicago and the suburbs for about seven hours a day and the coolant temperature was recorded at several stations in the engine. Each truck was equipped with a line thermostat and one of them had the cooling system augmented by air flow controlling shutters. The shutters were either fully open or fully closed, with the opening point set at 180 F. Recording of engine inlet temperatures made at ambient temperatures ranging from 37–85 F gave the results of Fig. 1. It is apparent that the truck equipped with air flow controls maintained the coolant inlet temperature in the 160–170 F range, while the other truck showed temperature fluctuations between 135–170 F.

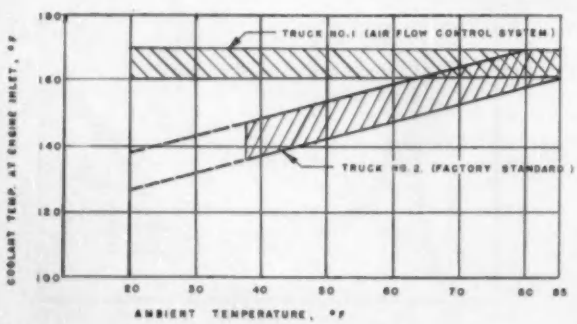


Fig. 1 — Superiority of a cooling system augmented by air flow control shutters is demonstrated here. The data was obtained from road tests conducted in the Chicago area.

The Kysor tests followed a similar procedure. Several trucks, all popular makes, were equipped with both a common line thermostat and an air flow control. Recording the temperature of the water entering and leaving the engine while each vehicle was driven over different routes, gave results like those in Fig. 2. The two charts give data on the temperature of the water at the two points of interest for one of the test trucks. Half of each chart shows results when the engine was operated with the common line thermostat only, and the other half is for operation utilizing both air flow control and the line thermostat.

In the particular case shown, the water outlet temperature with air flow control was maintained at a mean value of 182 F, with a range of 5 F. With the line thermostat only, the temperature was fairly constant at 160 F.

A look at the water inlet chart shows the major difference in the two systems. With air flow control the temperature drop across the radiator is consistently 10 F or less. Under line thermostat control the temperature drop was at an alarming value . . . greater than 50 F. Similar results for other trucks were also obtained.

These results are important because no vehicle

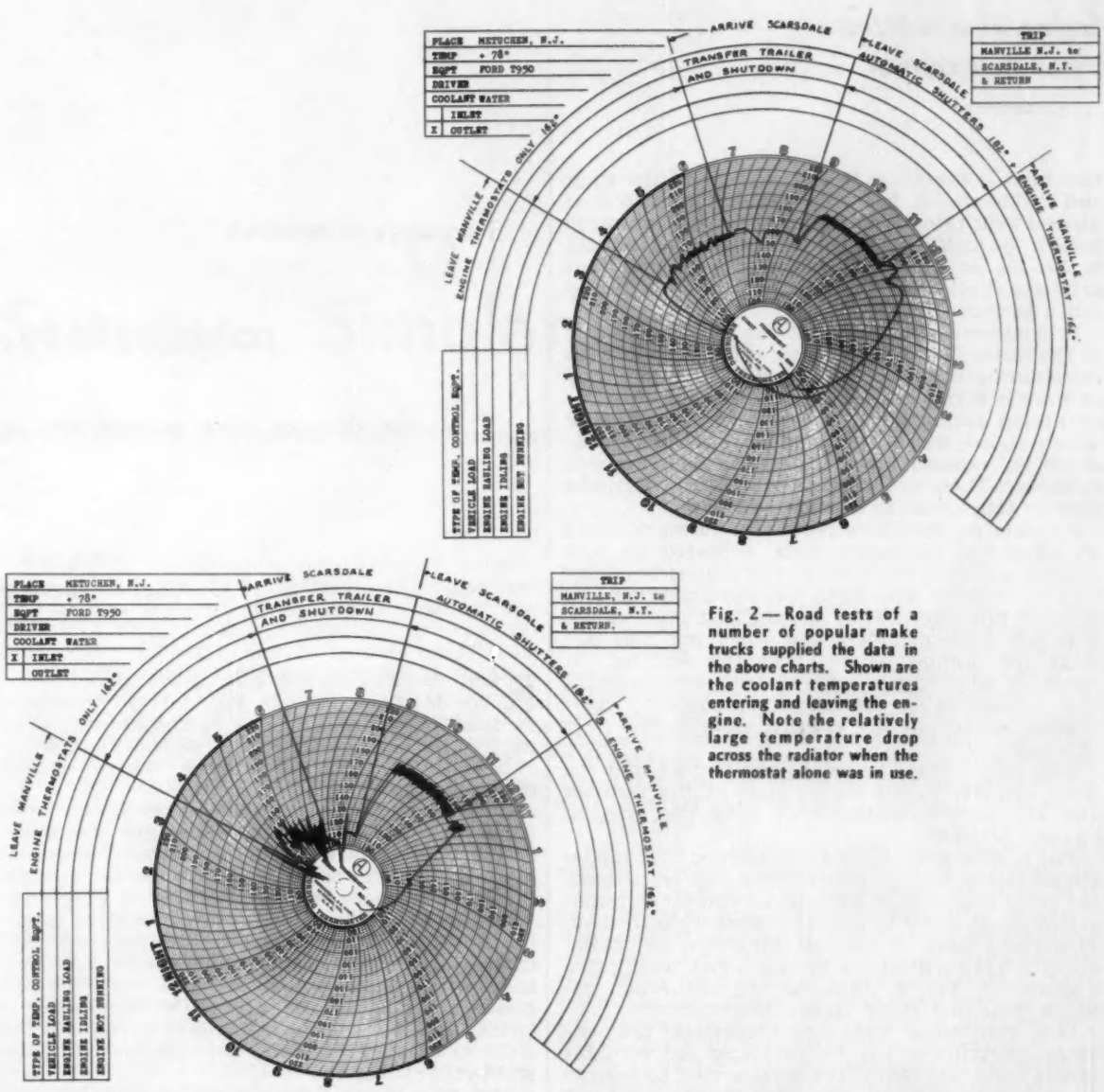


Fig. 2 — Road tests of a number of popular make trucks supplied the data in the above charts. Shown are the coolant temperatures entering and leaving the engine. Note the relatively large temperature drop across the radiator when the thermostat alone was in use.

with a conventional cooling system, even at this late date, is capable of operating in ambient temperatures ranging from well below zero to above 90 F . . . and still maintain an efficient and constant operating temperature at all times. Cooling systems today are substantially the same as they were years ago, (except, perhaps, for pressure caps). In general they are designed with sufficient water circulation and radiation surface to permit continuous operation at full power in 100 F air . . . without overheating. Under any other conditions the cooling capacity is far in excess of that required.

Lower wear rate seen

Preoccupation with the age-old worry of overheating has overshadowed the real need of sufficient heat to support clean combustion. A prime reason

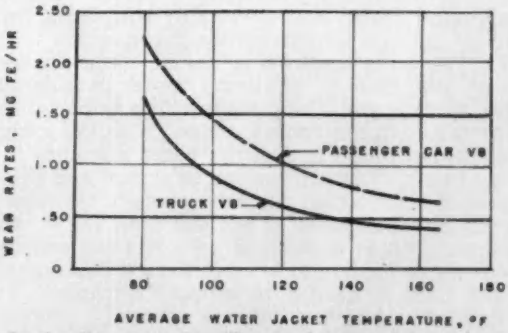


Fig. 3 — Wear rates (in milligrams of iron per hr) are shown to be greatly reduced when the average water temperature is higher. This data was obtained by using radioactive piston rings and periodically measuring the radiativity of the crankcase oil. The rings were weighed before and after the tests to confirm the results.

Engine wear reduced by air flow control

. . . continued

why heat is needed is to reduce wear of the rings and cylinders. It has long been established that highest wear rates occur during the engine warm-up period. At first, insufficient lubrication was thought to be the cause — but experiments showed that artificial lubrication provided during this period failed to reduce wear.

It is currently believed that the low temperature in the water jacket is the basic cause of high wear rates during the warm-up period. The mechanism at work is corrosion. At the low temperatures encountered during warm-up, an environment exists which allows the products of combustion to condense on exposed piston rings and cylinder wall surfaces. These products contain highly corrosive organic acids, sulphur trioxide, and water.

As early as the 1920's reports of research based on extensive laboratory tests appeared in SAE Journal outlining the influence of engine temperature on cylinder wall wear, oil contamination and filtering processes. They showed that most of the iron lost from cylinders and rings was corroded away, not abraded or cut from the surfaces. It appeared that higher cylinder wall temperatures were needed to let the harmful products of combustion escape out the exhaust valve in the form of vapors.

Even before these reports it was noticed that the front cylinder in the direct blast of the radiator and fan usually appeared to have the greatest amount of wear.

The recent Armour tests also showed that higher temperatures help to reduce wear. In these tests, the front cylinders of the engines contained radioactive piston rings to facilitate wear measurement. Frequently taken oil samples, measured for radioactivity, gave indications of piston ring wear rates. The results, Fig. 3, point out the connection between wear and water jacket temperature.

It is also found, from long experience, that engines operating at low temperatures are veritable sludge factories. Without adequate heat to support clean combustion the chemical mixtures formed in the engine collect and eventually transform the crankcase oil into a non-lubricating dilution . . . sludge. The large amounts of sludge found in vehicles on low mileage multistop routes, compared to those on long runs, help confirm the importance of temperature in controlling sludge. Also, the lower sludge buildup found in summer bears this out.

To accomplish the elimination of sludge and support proper combustion, an even coolant temperature must be maintained at not less than 180 F. In this respect, proper temperature control can reduce the need for using detergent oils. Even if detergents are used, heat is needed to support filtration. It is an important fact that oils are efficiently filtered only when their temperatures are high enough to make them 100 sec oils.

To Order Paper No. SP-194 . . .
from which material for this article was drawn, see p. 6.

Two ways to research

road safety:

In the absence of a comprehensive

Based on paper by
John Versace
Chrysler Corp.

ROAD SAFETY RESEARCH admits to two methods of attack. In one, the "survey" technique, we take the world as we find it, and describe what we find as best we can. The second method includes experimental techniques, where desired situations can be created.

In the survey approach, the number of cars passing certain points on the highway might be counted, or the number of accidents on holiday weekends totaled. Accident or police records can be searched for regularities in the personalities of people involved in accidents. Trends may be sought in the identification of car features associated with accident injury. It is never certain, though, that some unknown variable, which co-varies with the one under investigation, might not be the causative agent. In other words, all else is often not equal in a survey because it is solely dependent on statistics and not controllable.

The experimental method offers the advantage of control over situations rather than taking situations as they are found. With this technique the use of simulation is often advisable for reasons of cost, safety, and efficiency. Real-life experimentation of the scope envisioned simply cound not be carried out.

How, for example, could a dozen theories about highway interchange patterns be compared when they cost so much? It would similarly be unwise to study driving under hazardous conditions on a real road, though some investigators have taken their chances. Experimental efficiency is very important since control of conditions is essential for valid conclusions.

There has been much interest in recent years in the design and construction of large-scale universal-purpose simulators to study the driving process. A number of areas of investigation lend themselves to study on such a simulator.

Survey and Simulation

theory of driving behavior, these approaches must suffice.

Ordinarily, in the automotive industry, driving research is carried out to determine driver-car performance as a function of different vehicle dynamics, control-system parameters, and so on. Outside the industry, research is more oriented to learning the effect of personal, social, and medical influences. The effects of such things as drugs, social attitudes, and emotional impairment are studied. It is possible that certain vehicle parameters might interact with some of these personal-social-medical conditions, or with certain highway design features.

Studying the system formed by the road-driver-vehicle combination presents the problem of measuring performance, or system functioning. An experiment is pointless if no measurements can be made. Often, psychological measurements are wanted. These demand precise control over the condition being studied, and a simulation fidelity that may be crucial.

The measurements must be a reliable, fairly accurate index of what is going on. Attaining measurement reliability is bound to the question of what to measure. Since traffic safety is our interest here, the most relevent measure would seem to be an accident or accident fatality count . . . but these occurrences are so infrequent. In an experimental program, there is usually not the time or facility for simulating the millions of vehicle miles necessary to arrive at a stable, reliable estimate of accident rate.

Suppose, for instance, that the better of two intersection configurations is to be established experimentally. Also assume that the worst of the two leads to an average of two accidents in every 100 times a certain critical event occurs there, and the other leads to only half such an accident rate. It would take some 40,000 incidents in each of the two conditions to detect the substantial improvement. Still, there would be a 1 out of 20 risk of failing to notice the improvement.

Instead of measuring accident frequency, the ultimate criterion, one of the subordinate criteria leading to it may be studied. Measurement of subordinate criteria can often be made more reliably, and with vastly reduced exposure. Thus, if it could be established that deviant brain waves are associated with traffic accidents, the measurement of brain waves from a subject driving a simulator would be an indirect way of getting at the final criterion, number of accidents. Certain brain waves have been associated with drowsiness, or inattentiveness, so there is good reason to believe that there is an eventual effect on traffic accidents. But often, these indirect, or subordinate measurements are only assumed to be related to the final criterion of traffic safety.

The question of simulator realism must be answered for each research problem that arises. In some cases a completely abstract and artificial kind of simulation environment is adequate. Since a large element of driving behavior can be regarded as a risk-taking function, it may be that a pair of dice would be a suitable simulator for some purposes. In fact, there has been some research linking characteristic ways of assessing chances and risk-taking with basic personality structure.

It may be desirable and necessary to use simulation conditions that are deliberately unrealistic in surface appearance. For example, a study of how the human driver makes use of visual information can perhaps best be studied in an experimental set up in which his visual information is fractionated into orderly and systematic bits. The description of his environment is then amenable to mathematical specification, thus opening the way to a systematic and informed manipulation of these conditions so that their influence on driver behavior can be determined.

Specifications for research simulators is limited by the general absence of a comprehensive theory of driving behavior. In fact, a detailed theory including mathematical formulation of axioms and postulates, from which would stem specific hypotheses to be evaluated, would be a major achievement in driving research.

To Order Paper No. 366B . . .
from which material for this article was drawn, see p. 6.

Know your plastics

More types are available, physical properties have been much improved, and prices are lower

Based on paper by

T. H. Risk, J. R. Forrester, and R. P. Schmuckal
Ford Motor Co.

PLASTICS technology continues on the move. New thermoplastics are being developed and old ones modified to have properties far superior to those of only a few years ago. And as they get better, plastics seem to get cheaper, too.

Engineers are not yet taking full advantage of what present-day plastics have to offer in the combination of superior properties and cost. If they use imagination and apply sound engineering to the design of components, based upon the peculiar properties of plastics and unhampered by former configurations and design preconceptions, the payoff could be even better performance and appearance and lower cost.

Cost comparisons

COSTS can be compared in two ways: the price per pound and the price per cubic inch. On a weight basis, plastics are unlikely to become as cheap as steel. However, they are much lighter than steel and aluminum so that on a volume basis the price difference is much less. Methacrylate, ABS (acrylonitrile-butadiene-styrene terpolymers), polyethylene and polypropylene are cheaper than aluminum on a volume basis and polyethylene and polypropylene are cheaper than steel.

Comparing the "average" plastic with steel and aluminum on both weight and volume basis reveals plastics to have decreased 34.5% in price during the past six years, while steel has increased 20%. On a volume basis the plastics average cost is lower than aluminum and rapidly approaching the cost of steel.

The automotive design engineer who would use plastics today must first set down the most important property requirements and then study the properties and costs of the most likely plastics. After screening materials down to one or two, or maybe three, the final selection is made on the basis of functional tests of the finished component, sometimes in the laboratory, but ultimately on the vehicle.

Plastic types compared

TO ASSIST in the screening process, seven thermoplastics of greatest current interest have been compared on the basis of eight properties common to most plastics and of greatest concern to the design engineer. These comparisons will be found on pages 84–85.

In each graph, the plastics are arranged in descending order of excellence with respect to the physical property plotted. The bar graph gives the range of values obtainable in commercially available types. The vertical line within the range represents a typical value for the type of plastic now enjoying widespread use in the automotive industry. In the heat distortion temperature chart, two ranges of value are shown with a typical value for each range. The higher temperature range represents a 66-psi stress level, the lower range a 264-psi stress level. Here the plastics are arranged in descending order of excellence with respect to heat distortion temperature at the higher stress level. At the lower stress level the order changes. The solid bar indicates the overlapping of the two ranges.

Choice involves compromise

IMPROVEMENT in one physical property usually results in the sacrifice of another, hence the design engineer must determine the most important and least important and be guided accordingly. Among the nylons, for example, high tensile, high modulus, and high hardness are gained at the expense of elongation and impact strength, and conversely. With the ABS materials, formulated to cover a wide range of flexibility, the choice must be made between high hardness and high heat distortion temperatures on the one hand and high elongation and high impact strength on the other.

Nylon

MORE PLASTIC components are made of nylon than of any other material, but its use is usually limited to functional parts of small size because of its relatively high cost. The current price is $0.98/lb, $1.10/lb-vol (cost/lb-vol = cost/lb × sp gr).

Nylon is one of the strongest and stiffest of the thermoplastics. It has relatively good impact strength, low friction, high resistance to oils and fuels, high abrasion resistance, good electrical properties and high heat distortion temperatures, particularly at lower stress levels. These properties account for its popularity for bushings, carburetors, cams, windshield wiper and speedometer gears, door-latch wedges, electrical connectors, fuse holders and lamp bases.

Nylon has the drawback of being sensitive to moisture. Commonly used nylon stabilizes at about 2.5% moisture content at 50% relative humidity, increasing to 8.5% moisture content in water or 100% relative humidity. Increasing moisture content improves impact strength and elongation, but adversely affects strength, modulus, creep, and dimensional stability. Dimensional change amounts to about 0.020 in. per in. from an equilibrium condition at 50% relative humidity to equilibrium at 100% relative humidity.

Acetal plastic

ACETAL RESIN (polyformaldehyde) is a relative newcomer but already making a big impact. Its physical properties are more like nylon than the other plastics, and it is less costly than nylon. Current price is $0.65/lb, $0.93/lb-vol.

Acetal has strengths similar to nylon while its rigidity and stiffness are somewhat in excess of the stiffest types. It is comparable to nylon in resistance to heat under low stress conditions and significantly superior under high stress conditions. It is superior to nylon in low creep under load, higher load-carrying capacity, somewhat lower coefficient of thermal expansion, and relative insensitivity to moisture with accompanying improved dimensional stability. Its modulus is less temperature sensitive and it is better at withstanding sub-zero temperatures without embrittlement. Like nylon, it has outstanding resistance to fuels and oils.

This is one of the best thermoplastic engineering materials, but cost restricts its use. It is making inroads in the zinc die casting business, being used for interior door handles and window regulators, windshield washer pump housings, and on one production vehicle it is used for the instrument cluster housing. It is now being evaluated for fuel pump and carburetor components and gears. Increased use for bearings to eliminate periodic lubrication seems assured. In highly functional applications it appears to be the chief competitor with metals.

Polycarbonate thermoplastic

POLYCARBONATE is a relative newcomer with properties recommending it for special applications even at its present high price of $1.30/lb, $1.56/lb-vol. With lower price resulting from an increase in volume it could become competitive in cost with nylon and acetal.

This plastic has strength, modulus, and hardness properties comparable to those of many nylons and approaching those of acetal. It's exceptionally tough, with impact resistance exceeding that of any other rigid plastic because of its high modulus and high elongation. Although reduced considerably at low temperatures, the impact resistance at −40 F is still about twice that of acetal, its closest rival.

Polycarbonate is resistant to heat. As regards heat distortion temperatures, its performance does not vary significantly with load. At high stress levels it far surpasses other thermoplastics. Cold flow will not occur at stress levels up to one-fifth its ultimate strength. Other properties are creep resistance, dimensional stability, relative insensitivity to moisture, good electrical properties, and transparency if needed.

The combination of properties suggest polycarbonate use for transparent housings and dials, cams, latches, bushings, precision gears for operation at low speeds and light loads but subject to impact, and for impellers and propellers that may strike solid objects.

This plastic has its shortcomings. It should not be exposed continuously to oil and fuel, especially at elevated temperatures. Aromatic hydrocarbons are ruinous. It should not be used with antifreeze solutions or with water above 160 F. Its transparency is adversely affected by ultraviolet radiation.

Methacrylate

OUTSTANDING properties of this material are weather resistance, lustrous appearance, and optical properties. It has served for tail light lenses for more than 20 years without real competition. Current cost is $0.55/lb, $0.65/lb-vol.

Methacrylate is among the hardest of the thermoplastics and has high modulus and tensile strength. Elongation is low (3–5%), but impact resistance is adequate for the components in which it is used, Its impact strength is not reduced by temperatures down to −40F.

The high heat resisting types have heat distortion temperatures similar to the ABS materials, below those of nylon, acetal, and polycarbonates, and above polypropylene and polyethylenes. It is not a structural material because of brittleness. It is extremely notch-sensitive and cracks progress easily.

The automotive industry consumes half the output of this material for various light lenses, in-

strument lenses and cluster dials, horn button medallions, and other decorative items. It can be edge, flood and back lighted, or illuminated by piping the light through the part.

ABS materials

THE ABS FAMILY covers heat resistant, high strength grades, and medium impact, nylon-like grades. The range runs from the pliable to the rigid, the latter being discussed here. The cost is low — $0.49/lb, $0.52/lb-vol.

This material combines high-modulus, high-heat resistance with high surface hardness and high strength. Room-temperature modulus is higher than even that of acetal. ABS materials have lower heat distortion temperatures at low load levels than nylon and acetal, but higher heat distortion temperatures under high stress. Therefore, under low stress levels, nylon and acetal are usable at substantially higher temperatures than ABS, but the reverse is true at high stress levels. Creep resistance is superior to that of nylon and comparable to that of acetal. ABS is superior to nylon in insensitivity to moisture.

ABS materials are resistant to alcohols and to animal, vegetable, and mineral oils, but aromatic hydrocarbons cause swelling and softening. Environmental stress cracking differs with materials from different suppliers. Weathering usually causes discoloration, slight crazing, and loss of gloss, while ultraviolet exposure degrades in varying degree. The material should be subjected to environmental service testing before adoption.

Rigid ABS can be used for cams, knobs, push buttons, instrument cluster housings, dome light bezels, radio grilles, electrical condenser housings, battery caps, accelerator pedals, and perhaps entire instrument panels. Blown sheet with solid outer skins to form a sandwich is being used for boats and is being considered for automobiles. The material can be integrally colored, metallized, or painted.

Polyethylene H.D.

THERE are three general types of polyethylenes classified by ASTM as:

Type 1 — Low density (0.910–0.925 g/cm³).

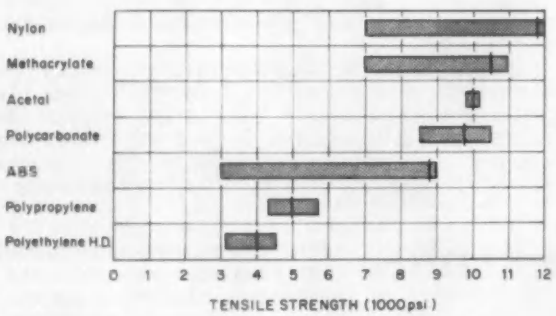
Type II — Intermediate density (0.926–0.940 g/cm³).

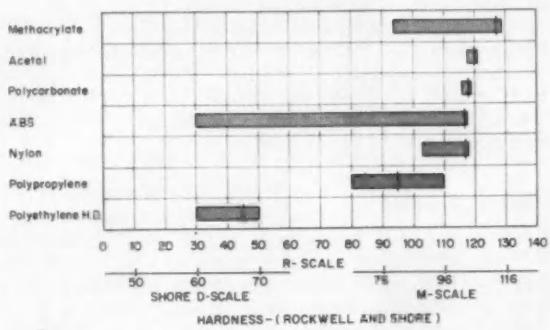
Type III — High density (0.941–0.965 g/cm³).

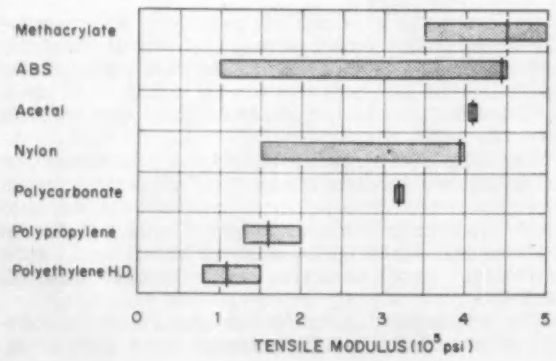
The high-density type offers higher rigidity, higher temperature resistance, and better chemical resistance. Current price is $0.35/lb, $0.33/lb-vol.

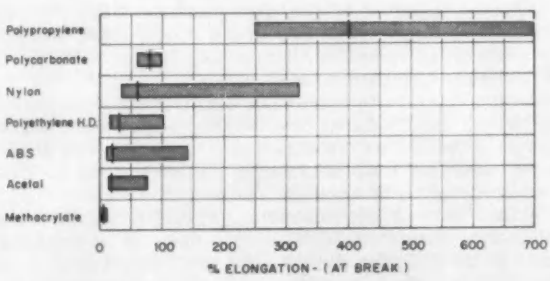
The high-density type has a waxy feel and very low friction. Ford has it under evaluation for lightly-loaded, low-speed bearings to obviate need for periodic lubrication. Its gasoline resistance and relatively low gas permeability suggest use in the fuel system.

Properties of









Among the plastics discussed here, polyethylene is lowest in hardness, tensile strength, and modulus. Under load it is subject to creep and distortion. About 150F is its upper limit of serviceability at low stress levels (66 psi), and about 115F at high stress levels (264 psi). Under extremely low or negligible load the maximum continuous service temperature exceeds 200F.

Its coefficient of thermal expansion is nearly 10 times that of steel and about twice that of certain ABS materials, consequently components must be designed to permit a high degree of expansion and contraction. Mold shrinkage characteristics often make it difficult to produce and maintain large flat areas within a part.

Despite its deficiencies, polyethylene has a place in the automotive industry. It has the merits of low cost per pound, low specific gravity, ease of coloring, and gloss, and it is easily fabricated by injection molding, vacuum forming, blow molding, thermofusion, and extrusion. It is satisfactory for side seat shields, window washer reservoirs, cowl kick panels, heater ducts and decorative items.

Polypropylene

THIS MATERIAL is twice as hard as high-density polyethylene and equal to many ABS materials, hence it has a fair degree of scratch resistance. Elongations at break of 400% are not uncommon and its flex life is exceedingly good. A polypropylene injection-molded accelerator pedal with integral hinge soon will show the advantages of the properties of this material.

Low temperature properties are considered poor because of notch sensitivity. A notched Isod specimen at – 40F shows practically no impact strength, yet the thin, radiused, hinge section of a pedal flexes continually without damage at – 40F. Thicker sections tend toward brittleness at low temperature.

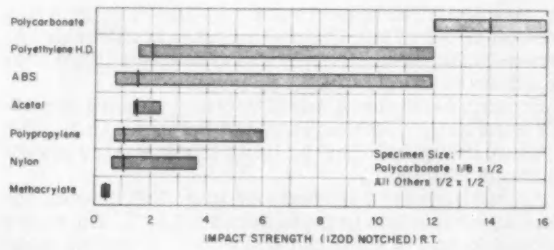
Heat resistance is superior to that of high-density polyethylene and comparable to that of ABS materials at low stress levels. However, the material is load sensitive and its heat distortion temperature drops drastically at high stress levels (140F at 264 psi). It has a high coefficient of thermal expansion which must be accommodated in component design. Chemical resistance is superior to that of polyethylene, but aromatic hydrocarbons attack severely at elevated temperatures. Unlike high-density polyethylene, it is not subject to environmental stress cracking.

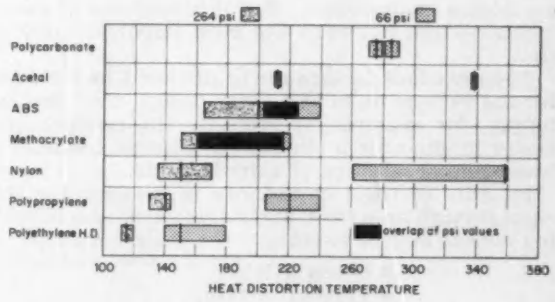
Polypropylene is used for luggage, textiles, and ropes and is now used, or will be used, in the automotive industry for dome-light lenses, cable connectors, seat kick panels, upholstery, tubing, radio grilles, and miscellaneous clips.

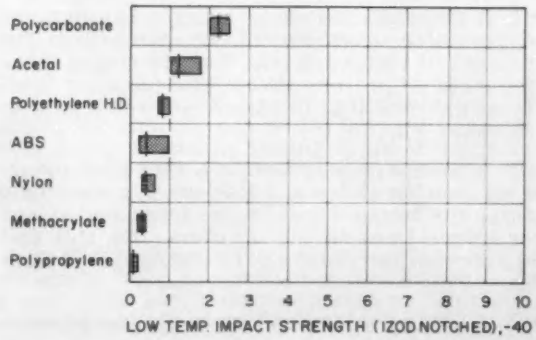
Current price is $0.42/lb, $0.38/lb-vol, or slightly higher than high-density polyethylene with which it is in competition. It also competes with ABS and premium-priced polymers.

To Order Paper No. 381A . . .
from which material for this article was drawn, see p. 6.

Leading Plastics







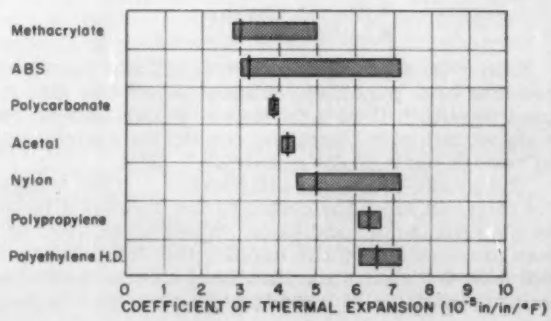
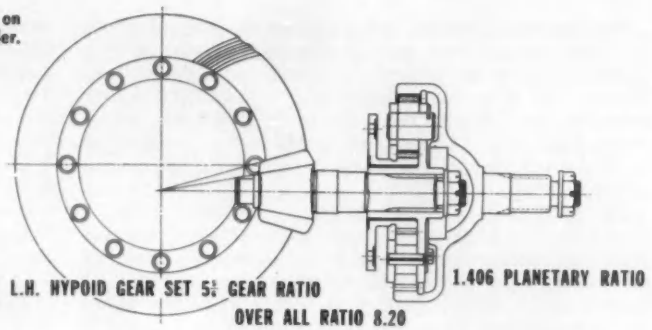


Fig. 1 — Planetary reduction on nose of single-reduction carrier.



Adapting driveline units to higher truck-engine

Based on paper by

N. R. Brownyer
Rockwell-Standard Corp.

HORSEPOWER does play an important part in determining what driveline units are best for a particular truck design. But it is only one of many factors — and not even the most important one at that.

These various factors are of different importance for the various units of a truck design, too. Engine torque, for example, is probably the number one factor in choosing a clutch. But torque assumes a lesser role in selection of a driving axle.

In order of their importance in determining the right driving axle for a particular truck, the following factors may be listed:

- Gross weight.
- Type of terrain.
- Road speed.
- Tire size.
- Axle ratios.
- Transmission ratios.
- Engine torque.
- Engine speed.
- Lubricants.

Higher horsepower, in other words can have both benefits and penalties, depending on the method used to obtain it in a particular design and on the wide variation in operating conditions encountered in various parts of the country.

The torque-absorbing members of a given vehicle, for instance, from the clutch to the tires are affected by a multitude of conditions. When all of these factors are tossed into the hopper, the designer comes out with driveline units that have a certain nominal capacity capable of handling the average vehicle of a certain gross weight class operating under predetermined conditions. So long as the same loads over the same terrain are maintained, any small change in engine power will be taken in stride.

The chief reason for using a higher horsepower engine is to maintain a higher average road speed by improving acceleration and pulling the grades faster. And, depending on *how* the higher horsepower is achieved, different driveline units have to be selected. Increase in permissible rpm to get a portion or all of the desired increase requires an increase in the overall numerical gear ratio. This may be achieved in one of several ways.

Present high-speed gasoline truck engines are being used with rear axle ratios of 6.8 to 7.2 to 1. (Up to now, designers tend to limit truck engine speeds to about 3600 rpm.)

An engine-speed increase of 10 or 11% means the rear axle ratio has to go to about 8.2 to 1. So, a new approach has to be taken to develop driveline components to operate satisfactorily with so high a gear reduction.

Engine speeds could be increased to about 4000 rpm, however, without increasing vehicle speeds in any one of a number of ways. For instance:

- 1. A planetary reduction between the flywheel and the clutch would benefit the clutch from the standpoint of reduced speed. But the torque input to the clutch, the transmission, the propeller shaft and rear axle would be increased and would have to be reckoned with.

- 2. A planetary reduction or a spur-gear reduction between the clutch and transmission also would increase the torque input to the transmission and other torque-transmitting members. So, this fact would have to be considered in the design of these units.

- 3. A permanent underdrive in the transmission

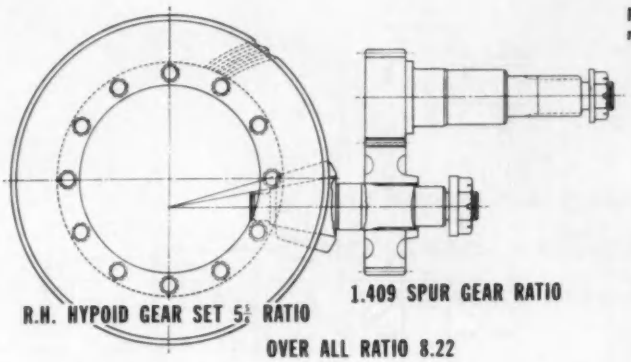
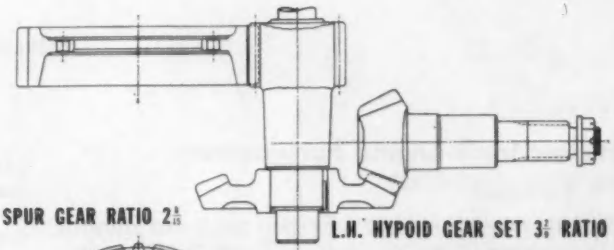


Fig. 2 — Spur-gear reduction on nose of single-reduction carrier.



horsepowers

Fig. 3 — Front-mounted double-reduction gear arrangement.

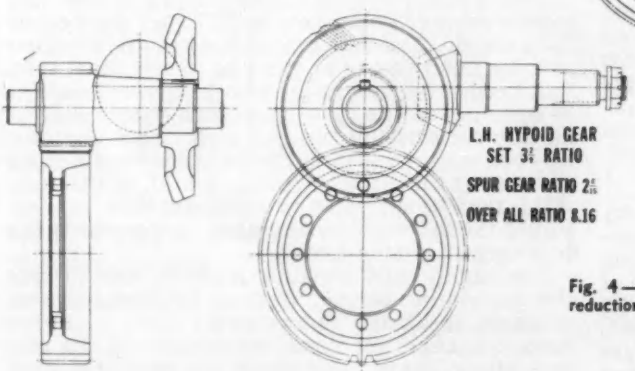


Fig. 4 — Top-mounted double-reduction gear arrangement.

by locking out the direct drive is the simplest way to increase engine speed without increasing vehicle speed — if increased performance is needed only at the top end.

• 4. A planetary or spur-gear reduction on the back of the transmission would have the beneficial effect of not necessarily loading up the transmission. Also it would slow down the propeller shaft. Here again, the torque capacity of all units back of the transmission would be affected.

• 5. With a planetary reduction on the nose of the gear carrier (Fig. 1) a relatively fast gear ratio can be used in the single-reduction carrier. This would insure a good pinion and bearing design.

• 6. With the spur-gear reduction on the nose of the single-reduction carrier shown in Fig. 2, good driveline geometry can be achieved even with a shortened propeller shaft in short wheelbase models. This construction requires a hypoid or bevel gear with left-hand spiral angle located to the right of the drive pinion for counter-clockwise rotation.

• 7. Use of the front-mounted double-reduction gear carrier shown in Fig. 3 has the advantage of accommodating any gear ratios needed in the foreseeable future. Penalty of this design is length — which will affect propeller-shaft geometry.

• 8. The double-reduction top-mounted design shown in Fig. 4 improves the propeller-shaft condi-

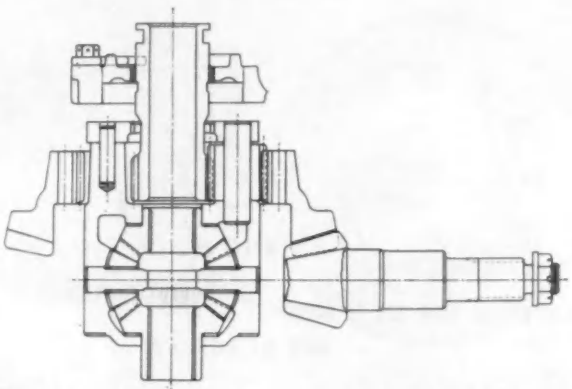


Fig. 5—Hypoid-planetary double-reduction carrier.

PLANETARY GEAR RATIO 1.417 L.H. HYPOID GEAR SET 5 5/6 RATIO

OVER ALL GEAR RATIO 8.26

Higher truck-engine horsepowers

. . . continued

tions by raising the rear universal joint and allowing for a longer propeller shaft. (These double-reduction designs allow for great latitude in choice of gear combinations to keep the pressure velocity at favorable levels. Actually, the slower ratio combinations in double-reduction axles have greater capacity than the fast gearsets. The opposite is true for single-reduction axles.)

• 9. A double reduction embodying a hypoid or bevel gearset in combination with a planetary system (Fig. 5) would allow the bevel gear or the hypoid set to have a ratio of about 6 to 1 to accommodate an overall axle reduction of 8.2. (Objection to this construction is possible high operating temperatures due to excessive oil churning in fast highway operation. . . . The ring gear travels about ⅓ faster than the final drive gear of a single-reduction or a conventional double-reduction axle.)

• 10. A planetary-type axle with the planetary gearing at the outer end with a single-reduction carrier of relatively low capacity at the center section is shown in Fig. 6. This construction permits use of extremely fast, single-reduction ratios to get the 8.2 overall axle ratio. (This construction can be justified best in off-road operation where loads are greater and high speeds are the exception — rather than in a highway vehicle.)

• 11. A pinion and bearing mounting for a unit with a normal gear ratio is shown at the top of Fig. 7; at the bottom is illustrated how — with the 7.2 ratio — the limit has been reached as far as pinion-shank size and inboard bearing support are concerned. The cutters actually gash the inboard support or spigot. . . . To overcome these shortcomings, the ring gear diameter would have to be increased excessively to get the desired ratio without drastically weakening the drive-pinion spigot.

• 12. Fig. 8 shows a way to use at the rear of the drive unit a set of transfer gears with a reduction that would allow for use of a relatively fast ratio (such as 5 5/6) in the bevel or hypoid set to accomplish the overall 8.2 reduction.

• 13. The single-reduction carrier with overhung pinion mounting shown in Fig. 9 has some penalty for pinion length, but seems a practical solution to the problem of increased power and gear ratio. By increasing the hypoid ring-gear size, the required ratio can be had; also an adequate shank and adequate bearings for the overhung pinion. This construction also copes best with heavy coast loads, such as those imposed by retarders and hand brakes.

When the engine's torque output is stepped up to produce the desired horsepower increase, a different solution to selection of driveline components is indicated.

Trucks equipped with diesels running at 2000 rpm require relatively fast axle ratios to get the desired road speed. And fast axle ratios require a higher average input torque at the axle pinion shaft than that needed for slow ratios with high-speed engines of equal power. So, slow-speed high-torque engines already use driveline units of high torque capacity. Any increase in this torque will require careful study for each of the driveline units. But all of the units WILL NOT be subjected to additional duty as a result of the increased power, when that power is due to increased engine torque.

The clutch most certainly must be able to take the full engine torque; so must the transmission, generally speaking. The propeller shaft would not need to change, nor would the capacity of the rear axle pinion shaft. Nor would the rear axle shaft and the differential have to be made bigger.

The only rear axle parts seriously affected by an increase in engine torque are the drive gear and drive pinion.

The economics of truck design involving weight and cost indicate that the greatest mechanical advantage should be as close to the road surface as possible. This means that the shortest radius tire should be used, because as much of the total gear reduction as possible should be in the axle proper.

In heavily loaded vehicles, the final reduction gearing should be in the wheel. Thus, the axle input pinion shaft, the propeller shaft, and the transmission system will be relieved of handling high torque values.

To Order Paper No. 386A . . .
from which material for this article was drawn, see p. 6.

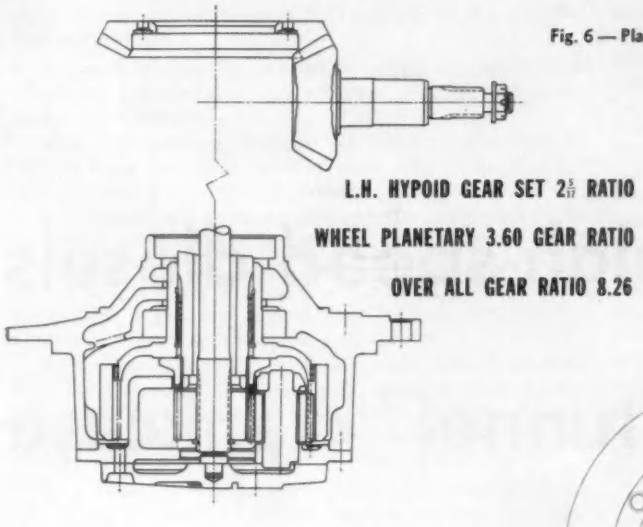


Fig. 6 — Planetary-type axle.

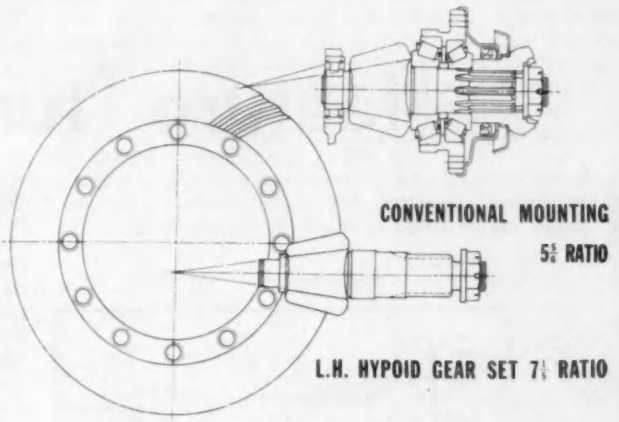


Fig. 7 — Straddle-mounted single-reduction carrier.

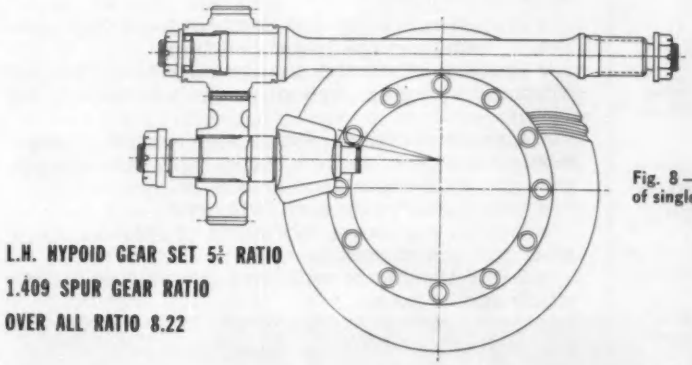


Fig. 8 — Transfer gears at rear of single-reduction carrier.

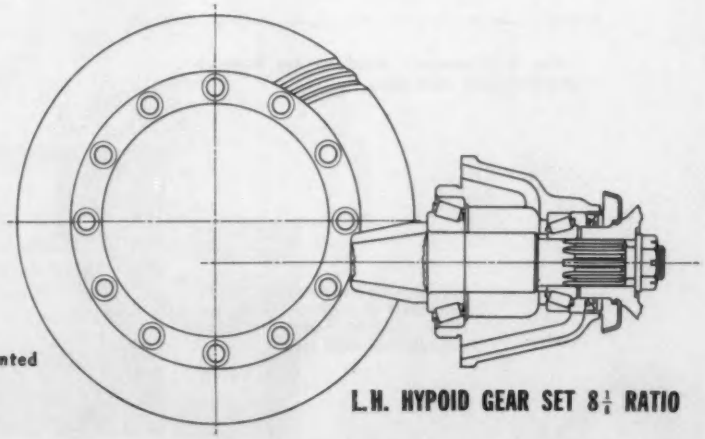


Fig. 9 — Overhung-mounted single-reduction carrier.

Maybach high-speed diesels feature "tunnel" crankcase

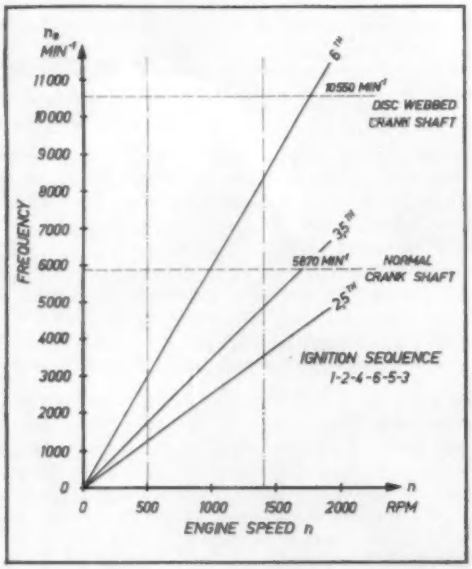


Fig. 1 — Resonance speeds of two Maybach crankshafts of about equal mass.

Based on paper by

Markus von Kienlin and G. W. Maybach

Maybach-Motorenbau GmbH, (Germany)

DESIGN features of the Maybach MD diesel engines include:

- Forged one-piece disc-webbed crankshaft carried in a single-piece tunnel housing.
- Pressure-oil-cooled aluminum pistons (forced-circulation cooling system) with detachable steel crowns.
- Individual cylinder heads with central precombustion chamber, and six small, well-cooled valves, with automatic backlash adjustment.
- Unit injectors for each cylinder.
- Tunnel crankcase fabricated of steel castings, steel plates, and profiles.
- Large number of repetitive components for the whole engine range.

Disc-webbed crankshaft and "tunnel" crankcase

In the MD design, almost the entire length of the engine is used for main and big-end bearings; the crankwebs, which in a conventional engine must be regarded as a loss in this respect, are here encircled

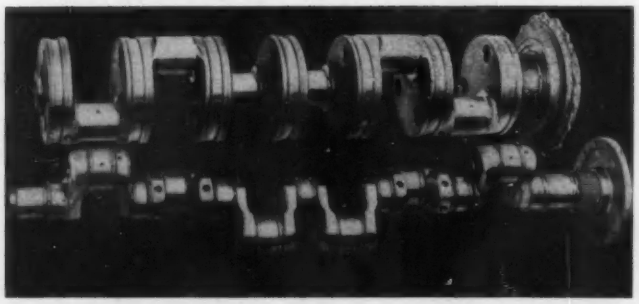


Fig. 2 — Comparison of normal crankshaft of high-speed Maybach diesel (bottom) with MD disc-webbed crankshaft (top).

by roller main bearings. This results in the following advantages:

- Short engine length with minimum distances between cylinders — this reduces elastic deformation and vibration.
- Considerable reduction of bending stresses to which the crankshaft is subjected, due to the crankwebs forming the main journals.
- Particularly good conditions for all crankshaft bearings, as these are generously dimensioned.
- Wide connecting-rod bearings of width nearly equal to diameter are used without danger of edge loading. Therefore, liquid film lubrication can be assured under all operating conditions.
- Due to the comparatively small dimensions of such a disc-webbed crankshaft, questions of material, flow of fibers, surface hardness, and quality are easier to solve than they are for larger-sized crankshafts, especially of slow-running engines.

As a result of its rugged construction and particularly of its shorter length, a disc-webbed crankshaft is at least 40% stiffer than a conventional crankshaft having a pin of the same diameter. In order to demonstrate this effect more clearly, the natural frequencies of a conventional crankshaft and a disc-webbed shaft have been compared in Fig. 1. The two shafts are illustrated in Fig. 2. The conventional crankshaft of the Maybach GO engine has a stiffness between two adjacent piston masses of 18.2×10^6 in.-lb/rad. Thus, the natural frequency of the engine alone, with flywheel but without vibration damper, becomes 5870 min^{-1}. Within the speed range between 500 and 1400 rpm the sixth order, which is very strong, is located at 980 rpm. On the other hand, the disc-webbed crankshaft of the rebuilt GTO or MD engine has a stiffness of 53.2×10^6 in.-lb/rad and a natural frequency of the engine alone without vibration damper of 10.55 min^{-1}. With this high first natural frequency, the sixth order lies outside the working speed range, and since higher orders do not need to be taken into consideration, the whole range from 500 to 1400 rpm is free from resonance.

The advantage of the disc-webbed crankshaft design is not as easy to see for torsional loads as for bending loads, because transfer of force from the crankpin to the web cannot be avoided even in a disc-webbed shaft. Nevertheless, the disc-webbed crankshaft still has superior form factors α_K related to torsional loads: $\alpha_K = 2.32$ for the disc-webbed crankshaft as compared with $\alpha_K = 2.79$ for the conventional crankshaft (Fig. 3).

Form factor refers to the ratio between the stresses actually measured in the fillet and those calculated for the pin. For the sake of better comparison, only the main stresses due to counterclockwise twisting of the shaft have been considered here.

Stress conditions are much more favorable in the disc of a disc-webbed crankshaft than in the crankweb of the conventional crankshaft. While there are hardly any elongation lines on the disc (Fig. 4), — that is, stresses, remain below 1400 psi — they are nearly as close in the conventional crankweb as they are in the fillet joining web to pin, because here the web is subjected to bending on one side, as is shown by the elongation lines in Fig. 4.

Advantage may be taken of the uneven distribution of stresses around the crankpin, as shown in Fig. 3 by arranging oil holes in areas where the main

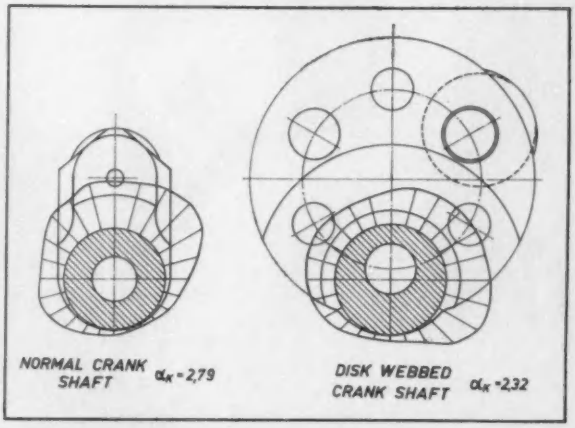


Fig. 3 — Stress distribution and form factors α_K for torque loading of normal and disc-webbed crankshaft.

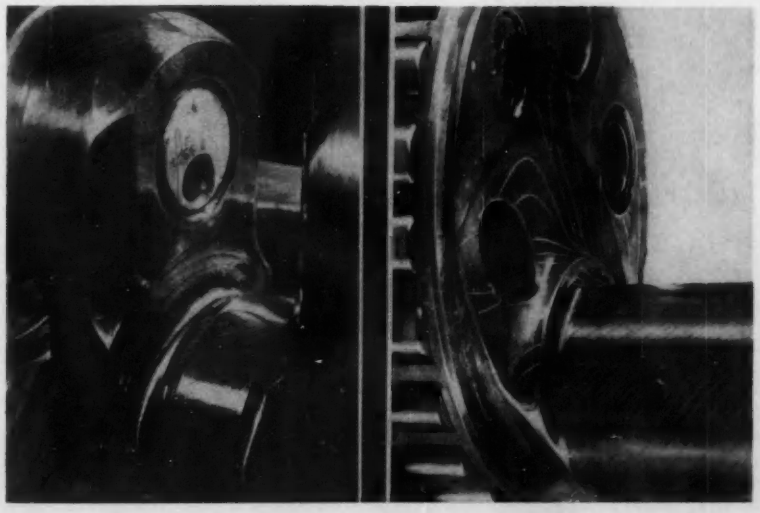


Fig. 4 — Comparison of strain lines in normal crankshaft (left) and disc-webbed crankshaft (right).

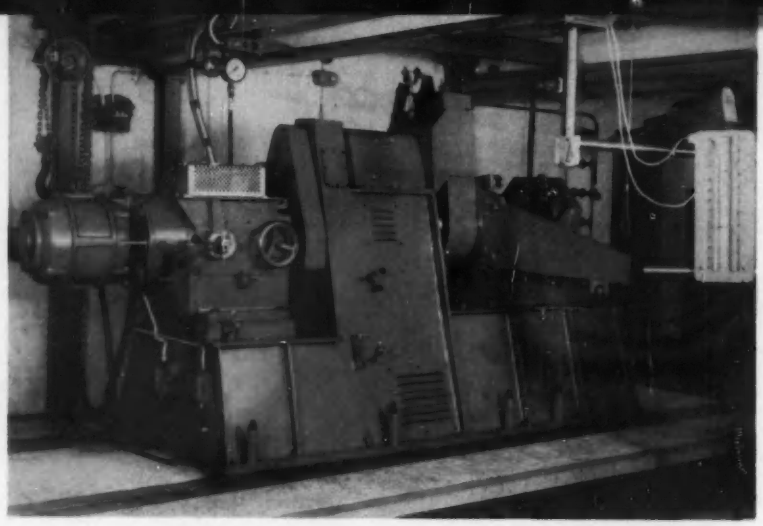


Fig. 5 — Test machine for torsional fatigue testing of crankshafts.

Maybach high-speed diesels feature "tunnel" crankcase

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stress is lowest, provided that no other reasons prevent this from being done.

When converting the Maybach GO engines into GTO types, and replacing the conventional crankshaft by the disc-webbed crankshaft, the main roller bearing diameter was enlarged considerably. A calculation shows how much the life of such a roller bearing is prolonged by enlarging the journal diameter, using for this purpose life data of standard roller bearings. A comparison of the loading capacity of a standard roller bearing with that of a wide-type bearing reveals that the load capacity is directly proportional to the width of the bearing roller (that is roller width less radii of the roundings). However, due to edge pressing effects, this width cannot be increased to an unlimited degree. Charts issued by various roller bearing manufacturers show that the load capacity C also increases proportionally to the mean diameter d_m of the bearing:

$$C = d_m \cdot n \cdot \xi \qquad (1)$$

where:

ξ = Constant

Therefore, the load capacity is independent of the roller diameter. A calculation using the equation of Hertz for contact load confirms this statement. Increasing the roller diameter reduces contact stresses, but since the number of bearing rollers is thereby reduced the gain is nullified.

Bearing life L_h may be obtained from the equation:

$$L_h = \left(f_n \frac{C}{P}\right)^3 \qquad (2)$$

where:

f_n = Speed factor
P = Bearing load

Comparison of the main roller bearing of the conventional GO-engine crankshaft with that of the disc-webbed crankshaft of the GTO and MD engines showed that the load capacity C in the disc-webbed crankshaft is 3.31 times larger. This means that the life is increased $3.31^3 = 36$ times. A numerical example will make this quite clear: In the case of the conventional crankshaft the life of the bearing, say, 1000 hr (approximately 45,000 miles in railcars), is increased to 36,000 hr, corresponding to 1,600,000 miles on change-over to the disc-webbed crankshaft.

Sufficient width is available on disc-webbed crankshafts for the design of a generous big-end plain bearing. Despite this increased width the danger of edge loading is very small. Due to the high torsional stiffness, in association with the high rigidity of the housing and the low wear of main bearings, the crankpin axis deviates in operation only very slightly relative to the crankcase axis. This has been verified by tests. Connecting rod bearings of the GTO and MD engines never showed any signs of excessive wear, even after several thousand hours of operation.

For crankshafts of high-speed engines, with comparatively small dimensions, high-quality steels can readily be used, thus permitting the use of higher grade heat-treatment and surface hardening. Heat-treatment of crankshafts with large dimensions for slow-speed engines is difficult and cannot be applied throughout. Crankshafts of small dimensions can be die-forged, which guarantees a flow of grain in accordance with the stress lines.

By proper surface heat-treatment the unfavorable effect of surface faults and scores which may be introduced during machining, or are due to the condition of the material, can be compensated.

However, according to Maybach experience and others, surface faults originating in the material have little or no effect on normal crankshafts because the effects of the notches incorporated in the design are greater. Therefore, it is all the more necessary to take into consideration the effects of quality of material, heat-treatment, and surface finish in order to be able to take full advantage of these improvements.

If fatigue strength and tensile strength of various crankshaft materials are compared, it is seen that an increased degree of heat-treatment does not always have the desired effect, because notch sensitivity of the material greatly increases with a higher degree of heat-treatment. From published literature and from Maybach research undertaken on a homemade torsional-fatigue test stand for crankshafts (Fig. 5) empirical findings have been plotted in Fig. 6 as the fatigue strength ratio τ_W/δ_B against the crankpin diameter. The upper limit curve shown here has been obtained from crankshafts with carefully arranged oil holes and large-radii fillets. The results obtained with the disc-webbed

crankshaft of the MD and GTO engine ranges coincide with the upper limit curve, indicating optimum design.

Fig. 6 shows another advantage of crankshafts for high-speed diesel engines, and thus of the Maybach disc-webbed crankshaft, in that the fatigue strength of crankshafts increases with decreasing diameter of the crankpins. As can be seen from this figure the crankpin diameter of slow-speed engines must not only be increased because of torque increase with the lower speed, but must be increased further to compensate for lower fatigue strength of crankshafts having large-diameter pins.

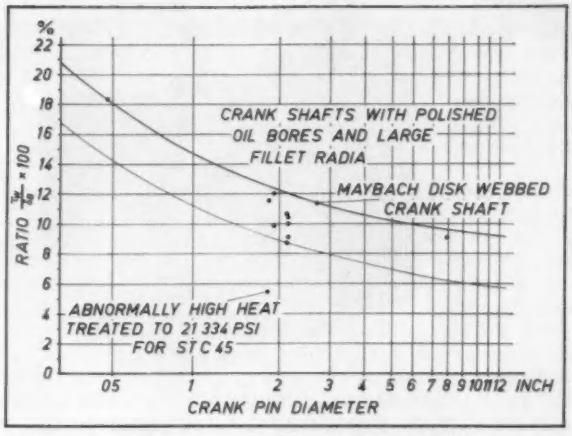

Fig. 6 — Torque fatigue strength of crankshafts as function of crankpin diameter.

Pistons with detachable steel crowns

In order to ensure complete reliability in continuous operation of engines with high mean effective pressures and to keep cylinder wear as low as possible, the MD engines were provided with pressure-oil-cooled pistons. These pistons are divided, consisting of piston barrel (of aluminum) and piston crown (of heat-resistant steel). A disassembled piston is shown in Fig. 7. Cooling oil is forced through a space left between skirt and crown, thereby effecting thorough cooling of the piston-ring lands which, even at high loads, are kept well below the critical temperature. Oil is supplied directly through a telescopic pipe and falls back to the crankcase over the small end, which is lubricated in this way. The following advantages for MD engines are obtained by piston cooling:

1. Absolute protection against piston-ring sticking and wear of grooves in the piston crown.
2. Reduction of the diametrical piston clearance to a fraction of what is considered normal for uncooled pistons.
3. Low lubricating oil consumption, which, at about 0.75% of the fuel consumption, comes very near to that of low-speed crosshead-type engines.
4. Simple and quick piston inspection, because, for a piston-ring check, just the steel crown fastened by six screws must be removed, without any need for dismounting pistons and rods.

Actual service results fully confirmed the expectations set into this design. Today, in practical operation, liner-wear figures of the order of 0.0004 in. per 1000 operating hr are expected. Thus, even if overall wear is limited to 0.016 in. in the interest of maintained low lubricating oil consumption, it can be seen that running performance is equal to that of the best low-speed engines.

Early difficulties due to corrosion attack of the liner walls from the cooling water side spoiled these low wear figures somewhat. Since, however, the outer surface of the liners are now chromium plated and corrosion inhibiting oils are now being used with the cooling water, corrosion has been entirely intercepted and full advantage can be taken of the low wear characteristic of the piston and liner design of the MD engine.

Individual cylinder heads

Next to the piston, the valves are the components most heavily loaded by the pressures and temperatures of combustion. In the MD engine the valves also have been designed to give maximum life and minimum wear.

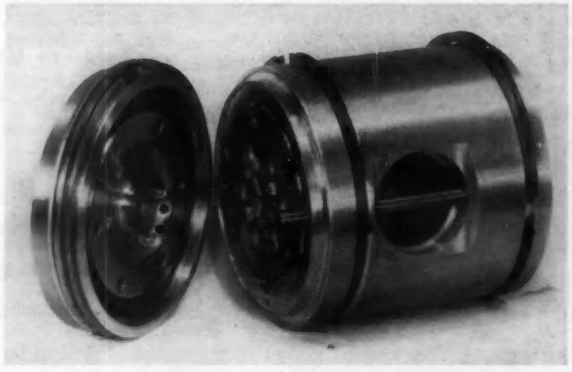

Fig. 7 — Piston crown (steel) and piston barrel (aluminum) of pressure-oil-cooled piston of MD engine.

The four valves of each 6.3-in. cylinder of the GTO engine produced running performance results which were regarded as extremely satisfactory, even when applying most stringent standards. In designing the MD range of engines, with the larger bore of 7.28 in., which could be realized as a result of piston cooling, it was felt that the well-proved valve dimensions should be retained.

This was accomplished by the use of three inlet and three exhaust valves per cylinder — six valves in all — concentrically arranged (Fig. 8) around the precombustion chamber and operated by rocker arms with small moving masses from overhead inlet and exhaust camshafts.

By these means small and thus lightly loaded valves could be used. As heating of a valve is proportional to the square of its head diameter, considerably less heat has to be dissipated from small-diameter valves and their stems; and this has a decisive influence on the service life of a valve.

To avoid heavy hammering of the rocker-arm rollers on the cams and of the valve heads on their seats, and to retain perfect functioning of the valve mechanism without necessitating frequent scheduled inspections, the valve gear is equipped with an

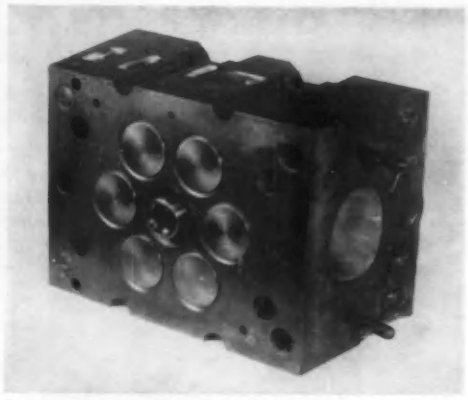

Fig. 8 — Single-cylinder head of MD engine.

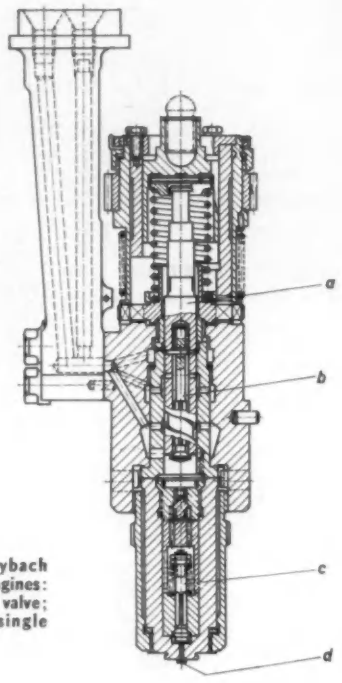

Fig. 9 — L'Orange-Maybach unit injector for MD engines: a — plunger; b — suction valve; c — nozzle valve; d — single hole nozzle.

Maybach high-speed diesels feature "tunnel" crankcase

. . . continued

automatic backlash adjustment. Special guides keep side thrust away from the valve stems.

Individual cylinder heads of all MD engines are identical and interchangeable. For sealing the combustion space iron rings are used, in contrast to commercial-type gaskets commonly employed in high-speed engines. These rings are subjected to the spring tension of relatively long cylinder head bolts, and so retightening in operation is unnecessary.

The camshaft-rocker arm assemblies for each cylinder bank are contained in a common housing, and the whole can be removed as an integral unit for piston checks, and refitted after inspection without any clearance adjustment.

Unit injectors for each cylinder

Fuel is injected into the cylinder head and connected with the cylinder by a multihole burner. The 6-valve arrangement permits a sturdy and well-cooled burner construction. Optimum conditions for combustion are obtained when the fuel is injected within the shortest possible time. Attempts to get these optimum conditions in high-speed engines of this size when using multiram injection pumps would lead to breathing of the high-pressure lines at each pump stroke, with detrimental effects on combustion.

Several years' close cooperation between Maybach Motorenbau and the L'Orange firm led to an injection device in which, by eliminating all pressure ducts, the pump was combined with the injection valve in a single unit (Fig. 9).

Each cylinder carries such a unit injector operated directly from the inlet camshaft by a rocker arm. All inconveniences associated with the usual injection pipes are thus eliminated. The fuel deliveries of all injectors in one cylinder bank is varied by the governor through a common regulating shaft.

Fabricated tunnel crankcase

At first MD crankcases were made of cast iron, but with the 12-cyl engine production became rather a difficult problem. There was also a desire to make crankcases more shockproof and facilitate repair in case of accident, particularly in the marine field. Therefore cast steel was considered as an alternative for all engines in the range. However, foundry practice did not permit a one-piece cast-steel crankcase.

Therefore, particularly when the 16-cyl model was revised, a change-over was made to fabricated construction, using steel castings, steel plates, and profiles welded up as one structure.

First, crankcase construction was arranged so all components were of convenient size, which meant that steel-casting thickness could be kept to 0.25 in., and so casting was easy and cheap; second, all welding seams were made easily accessible and kept away from highly stressed areas. Even in the construction process, a vital factor was to make as many rough parts uniform for all engines in the range, so that the manufacturing process itself could be repetitive.

In regard to weight a substantial advantage was also obtained from fabricated construction. Considering the 12-cyl MD engine the welded cast steel crankcase is 25% lighter than the corresponding

cast iron housing, and in the case of the 16-cyl engine it is approximately of the same weight as a cast aluminum crankcase for special applications having only 60% of the output of the steel engine.

The self-contained form of the tunnel housing, especially when fabricated of cast steel elements, gives it such stiffness that it may truly be regarded as the backbone of the engine. All engines of the MD range are preferably equipped today with fabricated steel crankcases.

Repetitive components for whole engine range

Diesel engines of higher output generally are not produced in such quantities as to permit the application of mass-production facilities. But reduced production costs can be gained by the unit-construction principles as adopted for Maybach MD engines, so that the individual models in the whole engine range differ chiefly by the number of cylinders.

The Maybach MD engine series, comprising 4-, 6-, 8-V, 12-V, and 16-V cyl models, extends over a power range between 300 and 3600 bhp. All these types have equal bore and stroke and all V-models have the same V-angle. Moreover, the subassemblies such as crankcase, crank assembly, pistons, injection system, oil and water pumps, valve gear, cylinder head, cam and rocker housing, exhaust turbocharger, and governor have been so unified that complete subassemblies, or at least the majority of their components, may be used equally for all models.

A 16-cyl MD engine without turbocharger or governor consists of about 6500 parts, but since many of these such as valve springs are the same, only 860 different scheduled parts are involved. Of these scheduled parts about 30% are specially intended for the 16-cyl model, whereas the balance may also be used for the other models. Of the 30%, the scheduled parts which depend on number of cylinders only come to about 14% (a total of 4900 single parts). Therefore, as much as 74% of all single parts of the 16-cyl engine are duplicate parts and can be used in all other models in the MD range as well.

All this has made economical production possible, so that, despite the high standard of design and construction compared with other makes, the Maybach MD range is absolutely competitive as far as price is concerned. Fig. 10 shows the 16-cyl MD 870 locomotive engine set to a rating of 2000 bhp at 1500 rpm. A cross-section and a longitudinal view of this engine are shown in Figs. 11 and 12, respectively.

To Order Paper No. 367A . . .
from which material for this article was drawn, see p. 6.

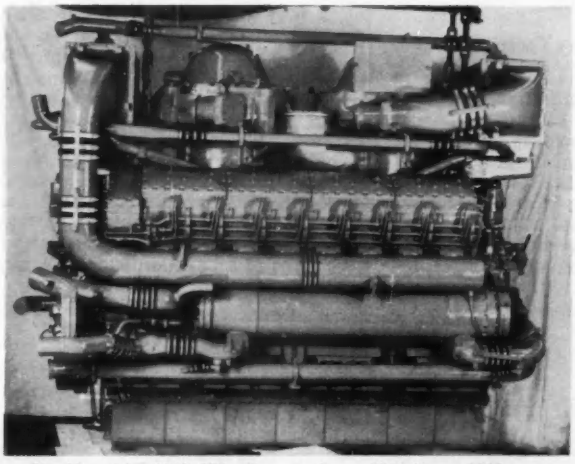

Fig. 10 — 16-cyl MD 870 railway engine — 2000 bhp at 1500 rpm.

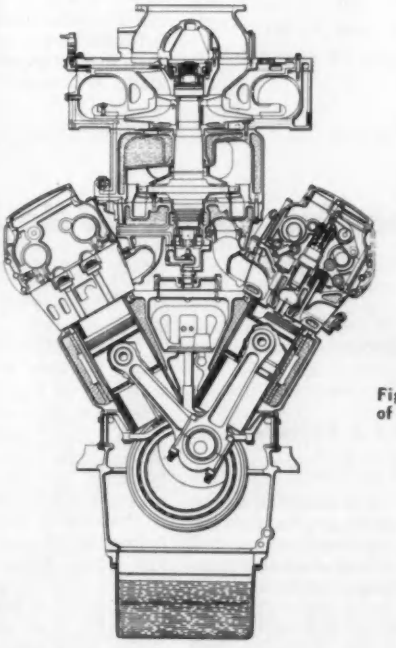

Fig. 11 — Cross-section of 16-cyl MD engine.

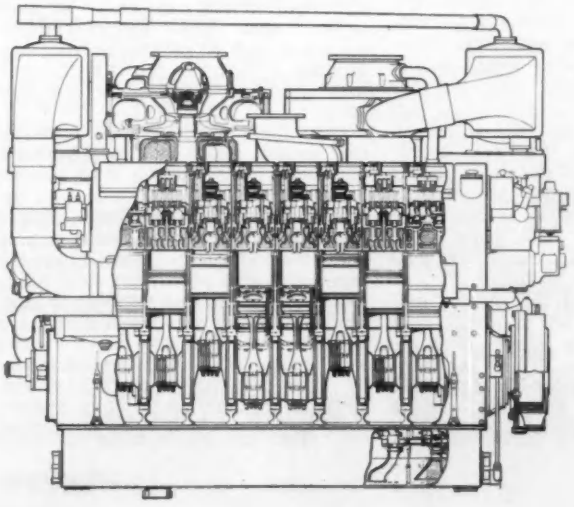

Fig. 12 — Longitudinal section of 16-cyl MD engine.

Poor Grease May Be the Culprit When

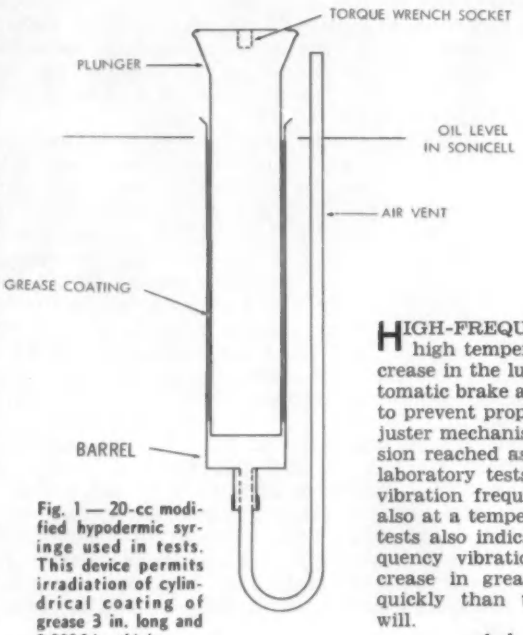

Fig. 1 — 20-cc modified hypodermic syringe used in tests. This device permits irradiation of cylindrical coating of grease 3 in. long and 0.0006 in. thick.

Based on paper by

W. F. SCRUGGS and T. W. SELBY

General Motors Research Laboratories

HIGH-FREQUENCY vibrations and high temperatures can cause a decrease in the lubricating quality of automatic brake adjuster grease sufficient to prevent proper operation of the adjuster mechanism. This is the conclusion reached as a result of a series of laboratory tests of three greases at a vibration frequency of 17,000 cps and also at a temperature of 250 F. These tests also indicated that the high-frequency vibrations will cause the decrease in grease quality much more quickly than the high temperatures will.

Laboratory Tests

Each grease contained a different type of particle: bentonite clay, graphite, or molybdenum disulfide.

Most of the tests were run in the modified 20-cc hypodermic syringe shown in Fig. 1. This allowed the testing of a thin coating of grease, such as is found in the actual adjuster. After each test, torque measurements were made to determine changes in the lubricating quality of the sample, as shown in Figs. 2 and 3.

Note that in each case the bentonite clay grease shows no torque increase with time of test, while both the other two greases show considerable increase.

Correlation with Road Tests

In actual road tests the adjusters lubricated with the bentonite clay grease operated properly beyond 20,000, and there was no loss of grease. With the graphite and molybdenum disulfide greases, on the other hand, there was a loss of grease after only 10,000–15,000 miles. This presumably led to improper operation of the adjusters because of the increase in friction between the contact surfaces of the socket, washers, and adjusting screw.

This shows that the lab tests were capable of predicting actual performance of the greases in service. Pictures taken at various stages of the vibration tests were examined to see if it was possible to determine the reason for the apparent correlation.

These pictures revealed that, as the testing proceeded, there was an increasing tendency for the particles to agglomerate and the base oil to separate out. This tendency was greatest for the graphite grease, somewhat less for the molybdenum sulfide grease. For the bentonite clay grease there were signs of separation of the oil, but

Best Ball Joint Grease Is Soft and Not Too Viscous

Based on paper by

A. C. HORTH and W. C. PATTENDEN

Imperial Oil, Ltd.

and

G. F. KELLER and J. PANZER

Esso Research & Engineering Co.

THE feedability of a grease into the bearing appears to be, by far, the most important property of a ball joint lubricant. Experimental results indicate that joints lubricated with hard greases are more often devoid of lubricant than joints lubricated with softer products. To lubricate ball joints properly, it appears that a grease has to be soft and not too viscous in order to be able to flow between the bearing surfaces.

This property of being able to flow appears, for example, to be important in overcoming fretting, which may be a primary cause of damage to ball joints.

The conditions under which ball joints operate are ideal for the occurrence of fretting corrosion. Fretting is a form of wear which results when two surfaces rub together wherein the motion may be linear, oscillating, or vibratory, but is always of small amplitude. The wear debris, in the case of ferrous metals, is usually converted to iron oxides; the familiar red oxide, alpha Fe_2O_3, is commonly formed and is the most likely to be noticed, but a black oxide, either FeO or Fe_3O_4, may also be found.

The amplitudes of the rocking motions in ball joints are sufficient most of the time to cause relative slips between the surfaces. Their range of frequencies covers those likely to cause fretting corrosion. Even the steering action is likely to produce this kind of bearing damage.

It is generally agreed that low viscosity base oils enable greases to minimize fretting corrosion to a greater extent than do base oils of higher viscosities. It has also been established that, if a grease does not feed adequately, fretting corrosion is promoted, and that simply adding materials such as oxides, molybdenum disulfide, graphite, or extreme-pressure agents to a stiff grease does not help.

Data from one field test indicates that greases made with high viscosity oils allow more fretting than greases made with low viscosity oils. In the same field test, the compound αFe_2O_3 was found in the wear debris coming from the ball joints. Laboratory experiments with plastic on steel joints separated the greases into two groups: the best greases were made with a low viscosity base oil; the worst greases were made with a high viscosity base oil. The laboratory experiments with sintered iron on steel joints showed that, as the consistency of the grease

Automatic Brake Adjusters Fail

the small size of the particles made it impossible to determine visually whether or not agglomeration had occurred.

Thus, it was not clear from these tests why the bentonite clay grease was so much more successful than the other two greases.

A search of the literature showed, however, that relatively low intensity sound waves (below the intensity necessary to cause cavitation) can produce coagulation of particles 1 micron or larger in diameter, whereas smaller particles (less than 0.5 micron in diameter) may not be affected.

In line with this theory, electron microscope photographs showed that the graphite particles in the grease were large and chunky, whereas the bentonite clay particles were smaller and platelike. The molybdenum disulfide particles were intermediate in size and shape. Note that the torque measurements taken after the vibration tests appeared in the same order as this.

Thus, the size and shape of the graphite and molybdenum disulfide particles may have made the greases containing them more susceptible to the effects of high-frequency vibration in the brake adjusters, and the syringe than the bentonite clay grease.

■ **To Order Paper No. 379H . . .** from which material for this article was drawn, see p. 6.

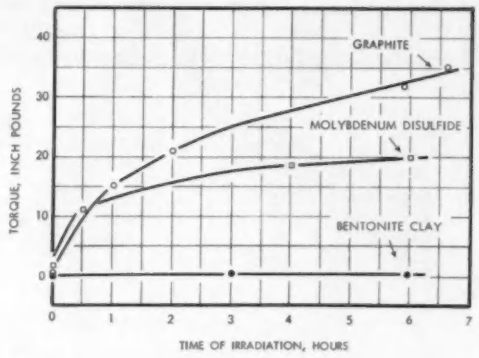

Fig. 2 — Torque measurements of greases after high-frequency vibration tests.

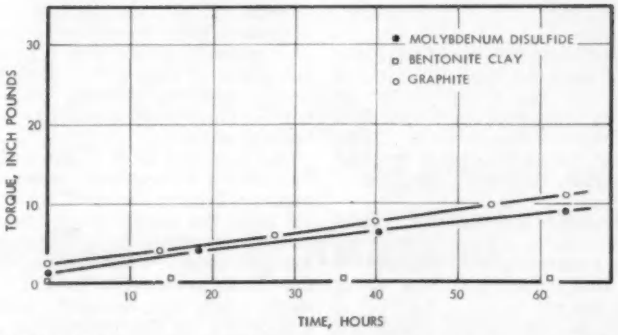

Fig. 3 — Torque measurements of greases after temperature tests at 250 F.

decreased, better ball joint lubrication resulted. The effect of additives is illustrated by using molybdenum disulfide in a lithium-calcium soap grease, which proved to be slightly detrimental, both from a friction standpoint (steering torque) and wear.

■ **To Order Paper No. 379B . . .** from which material for this article was drawn, see p. 6.

2-Stroke Engines Need Special Oils

Based on paper by

C. C. COLYER and W. L. SIEKER
American Oil Co.

THE higher horsepower of modern 2-stroke-cycle engines has brought a demand for improved motor oils to meet the more severe lubrication requirements of these engines. It has also increased the need for careful consideration of the fuel used, since the oil is supplied with the fuel and thus the components of the latter can have a great effect on oil performance.

Oil Studies

Field tests are now under way to evaluate a particular type of calcium sulfonate additive that, laboratory tests seem to show, provides the best overall performance when blended with a motor oil.

Test engines include various models of several makes of outboard engine: a 50-hp V-4, a 60-hp 6-cyl inline, a 40-hp 4-cyl inline, a 35-hp 2-cyl inline, an 18-hp 2-cyl inline, and several 8-hp aircooled chain-saw engines used in tree cutting.

The operating conditions normally used by boat owners and the tree cutting company are being followed.

Each engine has thus far accumulated 60–150 hr using the blend containing the calcium sulfonate additive that gave good results in the laboratory. No spark-plug fouling has occurred in any engine, and on periodic teardown the engines have been found to be clean. Previously these engines had used oils containing commercial calcium sulfonate and ashless additives. Then they frequently encountered spark-plug fouling within 50 hr.

Fuel Test Results

Limited laboratory tests using various types of gasoline in a 75-hp V-4 outboard engine indicate that gasoline additives have the following effects in 2-stroke-cycle engines:

- Lead reduces engine cleanliness and increases harmful combustion-chamber deposits.
- Phosphorus additives promote spark-plug fouling and preignition.

■ **To Order Paper No. 371A . . .** from which material for this article was drawn, see p. 6.

Thin Structure Shrinks Nuclear Heat Exchanger Size

Table 1 — Successively Subdivided Core, Straight-Passage Heat Exchanger

No. of Discs	Core Diameter and Length, in.	Core Volume, cu ft	Length of Each Disc, in.	Hydraulic Diameter, in.
1	66.8	136	66.8	0.512
2	47.1	47.8	23.6	0.222
4	33.3	16.9	8.33	0.090
8	23.6	6.00	2.95	0.038
16	16.7	2.11	1.04	0.016

Based on paper by

C. D. FULTON and W. B. THOMSON
General Electric Co.

A HIGHLY compact heat exchanger can be designed for high-powered versions of the gas-cooled reactor by reducing the heat exchanger to a thin structure with small passages. With the compact design, less fuel is required in the reactor, and less shielding is needed.

Example — Straight-Passage Heat Exchanger

Consider a certain gas turbine powerplant in the 100,000-hp class, using 1000 lb air per sec.

Solution of the proper equations gives a frontal area of 24.4 sq ft or a core diameter of 66.8 in. If core length is made equal to its diameter — to form an effective critical mass — core volume is 136 cu ft, which might result in excessive shield weight or installation costs.

Since little can be done about frontal area, the only practical recourse is to reduce the hydraulic diameter and length of the heat exchanger. The volume can be decreased without limit by this method. But the result is a thin, broad, porous disc that might be nuclearly and mechanically unacceptable.

What can be done is to slice up the core so that the heating-path length and hydraulic diameter are small, but the slices form a compact drum-shaped mass. Their aggregate frontal area will still be about 24.4 sq ft. One way of doing this is to make planar cuts across the core perpendicular to its axis. Let the core first be converted into one having two drums end-to-end with a narrow air gap between them. The core diameter and length will then fall from 66.8 in. to 47.1 in., and the volume from 136 cu ft to 47.8 cu ft. The hydraulic diameter will decrease from 0.512 in. to 0.222 in. The slicing process can be continued until the core becomes a stack of thin discs with small air spaces between. The process is recorded in Table 1. No allowance has been made for the volume of the air spaces between discs.

It is seen that this is a powerful method of reducing the core volume. It is also a powerful method of increasing the performance with a given volume. The process proves that a compact, high-performance air heater must be finely divided and have a short heating path.

The practical limit of the process of subdivision is reached when the air passages become too small for feasibility from the standpoint of manufacture or susceptibility to clogging with foreign matter. (The onset of laminar flow is not reached in Table 1 with 16 discs, where the Reynolds number is still 3900.) In this example, a practical limit may be somewhere between 4 and 8 discs with a volume of between 6 and 17 cu ft. Results will vary with the application. In view of the air spaces that must be added between discs, the final practical volume of the reactor core will be somewhat larger.

■ **To Order Paper No. 338B . . .**
from which material for this article was drawn, see p. 6.

Naval Demands Press Diesel Improvements

Based on paper by

R. W. CROWLEY
Bureau of ships, Department of Navy

DIESEL engines are losing out, in some cases, to other sources of power for naval applications. In the field of fast, short range craft, and for emergency power generation in large naval ships, the simple gas turbine is making considerable inroads. Also, because of the upward spiraling power requirements for each succeeding class of every type ship, steam power is frequently being employed where diesel engines formerly were used. The available engines often do not provide attractive installation because they are either too big or require too many units to do the job. However, there is promise that more attractive diesel will soon be available to power naval ships requiring up to 20,000 hp or more.

Diesels are also in danger of being pushed out of the picture for submarines and many other types of craft where minimum underwater noise output is vital to survival. More effort must be made to reduce the airborne noise output and engine vibration. This must be done at the same time that specific size and weight of diesel engines are being reduced. These requirements seem incompatible, however, reduction of engine size and weight usually means more cylinders of smaller size, higher speed, smaller torque vibrations, and better balance.

More emphasis must also be placed on increased engine accessibility and design for maintenance.

■ **To Order Paper No. 378A . . .**
from which material for this article was drawn, see p. 6.

Multiple Power Drives Become More Attractive

Based on paper by

R. M. SCHAEFER
Allison Division, GMC

THE ADVENT of the automatic truck transmission with torque converter and lockup clutch has furthered the concept of multiple power drives.

Trains of self-powered trucks, limited in number of units only by state regulations, constitute a new mode of transportation employing the multiple power concept.

In the oil fields, multiple power becomes possible because of the power balance produced by converters.

In earth moving equipment performance is increased by using a second engine to drive either trailer wheels or tandem axles; both engines are equipped with torque converter drives so as to effect a proper balance between the power trains.

In the railroad industry, self-powered railcars can be coupled to utilize the power of all units through the equalizing and power balancing ability of the torque converter. Units also can be uncoupled to handle short side runs from the main line.

In all applications of multiple power the common denominator is the balancing and synchronizing ability of the torque converter.

■ **To Order Paper No. 358B . . .**
from which material for this article was drawn, see p. 6.

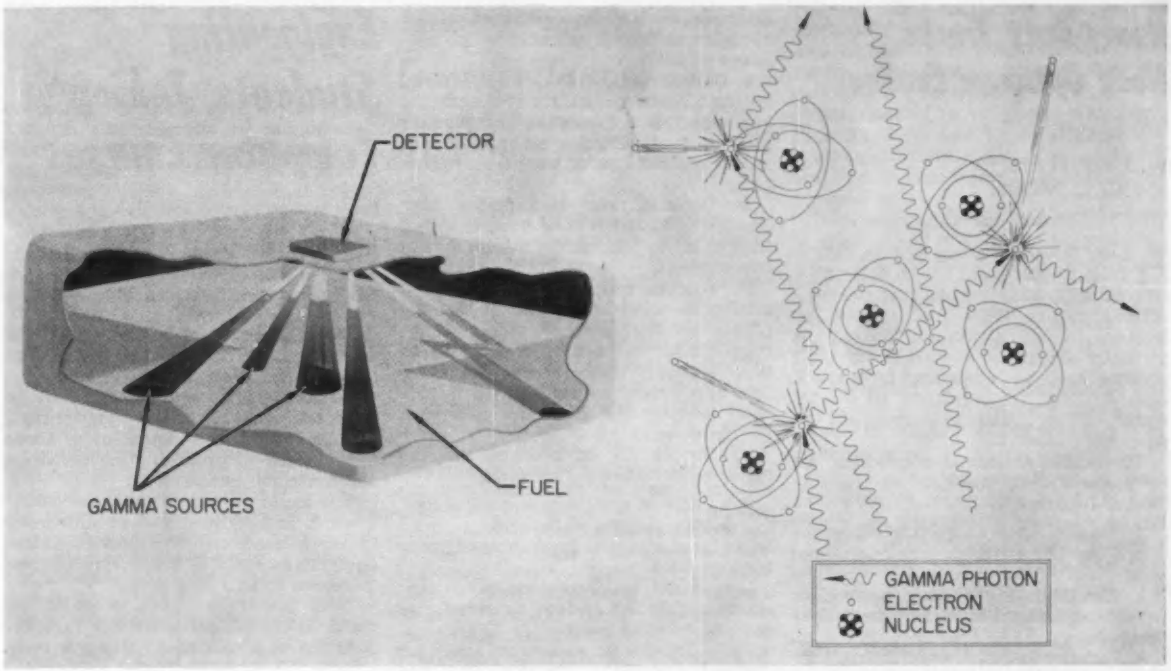

Fig. 1 — In new radiation fuel gage gamma photons are scattered and absorbed by interaction with electrons and fuel atoms.

New Fuel Gage Measures by Radiations

Based on paper by

C. F. BURNAP
Atomics International,
Division of North American Aviation, Inc.

A NEW radiation fuel gage measures by means of radioisotope gamma sources, a detector with the housing, a summing unit (in the case of aircraft with several fuel tanks), and the usual panel indicator.

The radioisotope gamma sources — usually Cobalt 60 or Cesium 137 — are placed around the fuel tank at strategic locations. Due to their very low level of activity, they do not present any radiological safety hazard to the personnel of the aircraft builder, the flight crew, nor the ground maintenance personnel.

Fig. 1 shows how this equipment works. The area at the right shows how the gamma rays bounce their way through the fuel and air space. Eventually some of them reach the detector, which adds them up, and sends a message to the indicator. Then the indicator tells the crew how many pounds of fuel remain in the tank.

Advantages claimed for this new device include: (1) fuel impurities have no effect on its operation; (2) payloads may therefore be increased as a result of the increased accuracy and reliability.

■ **To Order Paper No. 356C . . .** from which material for this article was drawn, see p. 6.

Brake Bonding Resins Important for Friction

Based on paper by

J. GEORGE OETZEL
Engineering Consultant

BONDING RESINS used in brakes seem to be a major contributor of friction . . . probably more so than any of the filler materials excepting possibly the abrasives . . . and these must be held by a strong bond to be most effective.

The nature of friction is apparently due to the interaction of the electrons of the materials in contact. The index of this condition seems to be related to the physical properties of hardness and resilience as they change with temperature. Though no tests are yet available to prove it, this indicates that even in those linings showing a rising coefficient at temperatures of 80–100 F, it will probably turn down again as the temperature drops and the bonding material gets harder and less resilient.

Probably accounting for this is the shortening of the electron orbits with temperature, which reduces the ability to interact with the mating material as well as making the friction material itself more brittle.

■ **To Order Paper No. 357A . . .** from which material for this article was drawn, see p. 6.

Heavy-Duty Trucks Need Optimum Cooling

Based on paper by

W. J. KOVELAN
and **C. L. MOON**
White Motor Co.

AN OPTIMUM cooling system differs from an adequate one in being able to cope with abnormal or extreme conditions rather than just normal or average ones. Optimum cooling is virtually synonymous with heavy-duty cooling, such as is required by a truck operating in temperatures of 100 F today and in subfreezing ambients tomorrow.

To handle abnormal conditions, an optimum cooling system has the following features:

1. Maintenance of cooling temperatures at or above a predetermined value.
2. A modulating bypass thermostat.
3. A permanent bypass or shunt system.
4. Balance to achieve effective, uniform cooling regardless of thermostat position, which means regardless of ambient temperatures.
5. High coolant flow rates without high working pressures.
6. Venting to facilitate system filling and prevent temperature drop on vehicle drift or part-throttle operation.
7. Efficient operation and effective cooling at high coolant temperatures and at atmospheric pressure conditions independent of high-pressure, pressure caps.
8. Ability to function and maintain stabilized water temperature with considerable coolant loss. This gives the operator sufficient warning to investigate and refill.
9. Self-purging of air entrained during fill, and capability of deaerating and purging combustion gas leakage into coolant without an appreciable loss of coolant flow or temperature stability.
10. Coolant flow to radiator high enough to assure a good cooling index, that is, air to boil, with a minimum fan requirement.
11. System coolant loss held to a minimum when operated at atmospheric conditions when stopping abruptly after a hard upgrade pull at high ambient temperatures. A pressure cap, acting as a check valve, further reduces the minimum loss to a negligible amount.
12. Proper use of a surge tank to achieve the following purposes:

a. Add to reserve water capacity.
b. Maintain a static pressure head at water pump inlet for improved pump performance.
c. Assist in deaeration of coolant at high point of system by serving as coolant settling basin.
d. Provide an expansion space for coolant, resulting in smaller and stronger radiator top tanks.
e. Application of low value pressure relief valves with high volume dump capacities protect system from fatigue failures.
f. Serve as a condensing area for coolant vapor.
g. Provide convenient filling through proper location.

(Material in this article is drawn from one of five papers included in SP-194 — Coolant Temperature Effects on Engine Life and Performance. To order SP-194, see p. 6.)

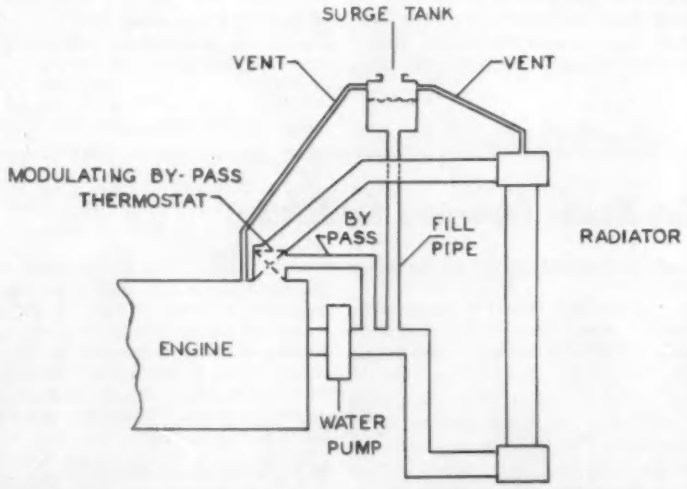

Fig. 1 — Salient features of an optimum engine cooling system designed for heavy-duty trucks.

Engineering Students Taking Computer Courses

Based on paper by

DONALD L. KATZ
and **BRICE CARNAHAN**
University of Michigan

MANY engineering students now are receiving instruction in the use of analog and digital computers. Graduates in the years ahead may be expected to approach engineering problems from the viewpoint of those experienced in programming problems for machine computation.

The rapid growth of machine computation in industry and in university research has convinced most educators that engineering students must be introduced to this new area.

Does the student gain a better insight into physical processes and the solution of problems by using a computer? Those experienced in machine computation say YES. The preparation of a working program requires rigorous and clear thinking. There can be no fuzzy statements in machine computation. Assumptions are likely to become more evident than before. Solutions of general cases are emphasized rather than specific situations.

Education should emphasize the structure of the problem rather than techniques of communicating with the machine. Algorithms or flow diagrams set forth the sequential operations for solving the problem. Learning to organize the algorithm should be the primary task of the student.

Problem-oriented languages such as FORTRAN, ALGOL, and MAD are available to the students for communicating with the computer. These languages process problems with relatively little time and effort required. Thus, coding procedures can be deemphasized and more time spent on organization of the algorithm.

Teaching Students to Program

At the University of Michigan, most engineering programs now require a sophomore course on Introduction to Computing Techniques which consists of one hour of lecture and one hour of recitation per week for 15 weeks.

The basic elements of the programming process are given in the lectures along with some introductory numerical methods. Computing Center personnel give the lectures; engineering teachers handle many of the recitation sections.

The students are given three problems to solve during the semester. These they solve using a flow diagram and a program written in problem-

oriented machine language.

Early Engineering Problems

Following an introduction to programming, students need to be taken through the solution of engineering problems of increasing complexity. This is done by beginning with simple problems, building on these, and finally reaching the more comprehensive ones.

As the student progresses through his engineering courses, it is expected that he will find one, two, or three problems each semester to be solved on the digital computer. Likewise in the area of dynamics or control, he should have the experience of solving problems on analog computers.

The Graduate

Graduates entering industry normally find computing facilities at their disposal. Within a matter of months, the young engineer normally will be given an assignment for which the computer would be useful. With a background of using computers in school, he should be able to recognize the proper place for their usage.

■ **To Order Paper No. 372A . . .** from which material for this article was drawn, see p. 6.

Industry Provides Computer Training Too

Based on paper by

J. L. DAVIE

McDonnell Aircraft Corp.

COMPUTER training programs in industry usually are geared to meet the requirements of:

1. A closed shop computing arrangement, or
2. An open shop computer service.

With a closed shop arrangement, all of the work connected with preparing programs, preparing data for production, and operating the equipment is done by members of a centralized computing department. Here, a group of computer specialists service the different divisions within the company.

As a computer is replaced by a later model, new programming methods, rewriting of existing programs, and development of new applications are necessary. This has been an internal training problem for the centralized computing facility.

An open shop group may consist of one large computer and a program staff consisting of people from the various departments serviced by the computer. The open shop group may also consist of smaller computers actually installed in the departments requiring their services.

The method of educating the engineer for these two types of organizations is different. So training classes must be flexible enough to satisfy the needs of both.

Instruction for the centralized environment will include the basic operations of a computer and a set of basic operation codes. By using these codes more time can be spent in class developing programs for actual problems from the various divisions of the company.

Instruction for the decentralized environment will require more time spent on programming methods and less time on applications.

Supervisors, too, should be trained in the use of computers. Only in this way, management will be aware of the capabilities and possibilities inherent in electronic data processing equipment . . . and plan their operations for optimum use of these powerful tools.

■ **To Order Paper No. 372B . . .** from which material for this article was drawn, see p. 6.

Computer training program for engineers at McDonnell Aircraft

SESSION I

1. General Introduction
   - 1.1 Background
   - 1.2 History
   - 1.3 McDonnell Experience
   - 1.4 Computer Components
   - 1.5 Hardware
   - 1.6 Systems
   - 1.7 Types of Computers

SESSION II

1. Specific Introduction
   - 1.1 Nomenclature
   - 1.2 Digital Computers
   - 1.3 Analog Computers
   - 1.4 Choice of Computer to Fit the Job
   - 1.5 Type of Problems that Can be Solved
   - 1.6 Method of Solving Problems

SESSION III

1. Equipment
   - 1.1 General Discussion of Computer Philosophy
   - 1.2 Questions and Answers and Review
   - 1.3 Description of Punched Cards
2. Introduction to Auxiliary Equipment
   - 2.1 Keypunch
   - 2.2 Verifier
   - 2.3 Preparation of Data for Keypunching

SESSION IV

1. Auxiliary Equipment
   - 1.1 Sorter
   - 1.2 Reproducer
   - 1.3 Collator
   - 1.4 Interpreter
   - 1.5 Printer
2. Field Trip of Auxiliary Equipment

SESSION V

1. Number Systems
   - 1.1 Decimal
   - 1.2 Octal
   - 1.3 Binary
   - 1.4 Bi-quinary
2. Methods of Handling Numbers in a Computer
   - 2.1 Floating Point
   - 2.2 Fixed Point
   - 2.3 Conversions
   - 2.4 Examples
3. Exercise Group I

SESSION VI

1. Continue Discussion of Conversion of Numbers
   - 1.1 Decimal to Binary
   - 1.2 Binary to Octal
   - 1.3 Decimal to Octal
   - 1.4 Octal to Decimal
   - 1.5 Binary to Decimal
2. Class Work
   - 2.1 Discussion of Exericses
   - 2.2 Assign Conversion Exercises
     - 2.2.1 Fixed
     - 2.2.2 Floating
   - 2.3 Discussion of Solutions

SESSION VII

1. Numerical Analysis
   - 1.1 Simultaneous Equations
   - 1.2 Extracting Roots
   - 1.3 Square Roots
   - 1.4 Polynomial Evaluation
2. Summary of First Half of Course

SESSION VIII

1. Discussion of Course Coverage for Second Half of Course
2. Mid-term Exam

SESSION IX

1. Symbolic Assembly Programming
   - 1.1 Definition of Computer
   - 1.2 Definition of Instructions
   - 1.3 Sample Programs
2. Exercise Group II

SESSION X

1. Discussion of Group II Exercises
2. Symbolic Assembly Programming
   - 2.1 Additional Instructions
   - 2.2 Use of Index Registers
   - 2.3 Sample Programs
2. Exercise Group III

SESSION XI

1. Discussion of Group III Exercises
2. Introduction to FORTRAN
   - 2.1 Philosophy of Automatic Programming
   - 2.2 FORTRAN Statements
   - 2.3 Samples
3. Exercise Group IV

SESSION XII

1. Discussion of Group IV Exercises
2. FORTRAN
   - 2.1 Statements
   - 2.2 Examples
   - 2.3 Discussion

SESSION XIII

1. Quiz
2. FORTRAN
   - 2.1 Statements
   - 2.2 Examples
   - 2.3 Discussion
3. Exercise Group V

SESSION XIV

1. Discussion Group V Exercises
2. Class Work
   - 2.1 Write Program
   - 2.2 Field Trip to Computer Room to Run Program

SESSION XV

1. General Review and Discussion

SESSION XVI

1. Final Exam

No Moving Parts—Feature of New Valves

by E. M. DEXTER
General Electric Co.

MAJOR CHANGES, in the form of controls without moving parts, are beginning to take place in the fluid power industry. Such devices, by their inherent simplicity, are desirable for getting higher reliability.

A good example is the no-moving-part check valve shown in Fig. 1. In the forward direction of flow this device presents a smooth path. In the reverse direction the contours of the flow channel provide a relatively high impedance. Impedance changes of up to 100 to 1 are claimed.

Another example is the Vortex valve consisting of an annular chamber, Fig. 2. The inlet flow is radial and the exit flow is along the axis of the annulus. A control jet close to the main flow inlet, and at 90 deg to it, deflects the main flow into a vortex spin within the chamber. The resulting centrifugal forces in the vortex cause a radial pressure gradient in some proportion to the control jet velocity. Thus, by varying the flow through the control jet, different pressure drops across the valve and total flows through the valve can be attained.

One application for such a valve might be a system in which a constant output force is required from an actuator. For this job the valve would need to have a constant pressure drop at any given control flow, for a range of total flow values. By placing the valve in parallel with the actuator and feeding the system from a constant supply source, the actuator force will remain fixed as long as the control flow is held constant, since the pressure drops across the units in parallel must be equal. A different, but constant, actuator force is achieved if the control flow is changed to a new level. The actuator force is directly proportional to control flow when the actuator flow is insignificant.

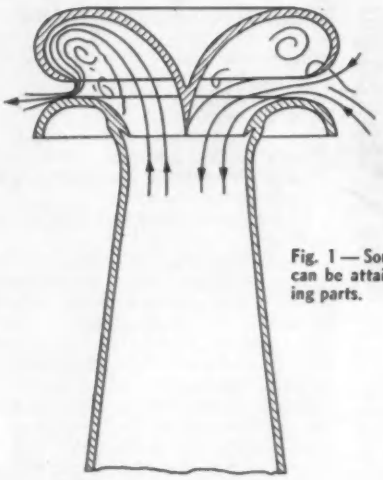

Fig. 1 — Some degree of check valve operation can be attained with this valve having no moving parts.

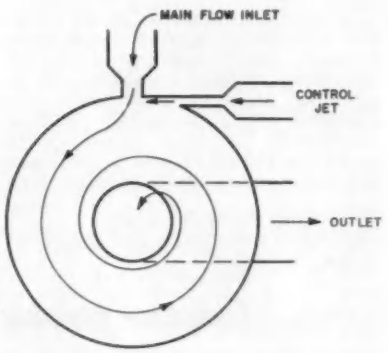

Fig. 2 — Vortex valve. The pressure drop across the valve can be varied by the control jet.

(Material in this digest is drawn from a paper presented at the 50th meeting of SAE Committee A6 — Aerospace Hydraulic and Pneumatic Systems and Equipment.)

Measuring Radiant Energy From Jet Combustor Flames

Based on paper by

R. M. SCHIRMER
Phillips Petroleum Co.

MEASUREMENT of total radiant energy from jet combustor flames should include the infrared spectral region through 5 microns, if reliable data are to be obtained, recent research indicates. This is because the radiation emitted by flames, typical of those obtained in jet engine combustors at atmospheric temperature, is not characterized by black body energy distribution . . . although gray body radiation is approached with increasing pressure.

These reliable data can be accomplished by use of sapphire optical materials and a suitably calibrated total radiation pyrometer.

The amount of radiant energy received from the flame zone can be modified significantly, it also was found, through absorption by quenched combustion products. Therefore, the radiation detector should be oriented from the surface of interest.

■ To Order Paper No. 379E . . . from which material for this article was drawn, see p. 6.

Overcoming Drum Brake Weak Points

Based on paper by

J. L. WINGE
The Bendix Corp.

HIGH EFFECTIVENESS makes the self-energized drum brake ideal for the typical American car because its small wheels in relation to vehicle weight restrict installation space. It also makes the brake relatively sensitive to variations, but this sensitivity can be reduced by proper designing, application, and selection of friction materials.

There are four important guides to follow to effect improvement. These are:

1. The coefficient of lining friction preferably should decrease moderately during the initial use of the lining and with increasing brake operating temperatures.
2. Select the lining with the lowest coefficient of friction consistent with satisfactory pedal efforts.
3. Design drum and brake shoes for the optimum relative flexibilities.
4. Hold the front wheel scrub radius to the minimum value effecting a satisfactory compromise between steering and braking considerations.

■ To Order Paper No. 361B . . . from which material for this article was drawn, see p. 6.

SAE NEWS

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A report from the BOARD OF DIRECTORS

At the June 9, 1961, meeting of the Board of Directors, the following actions were taken:

APPROVED

Discontinuance of New York **AERONAUTIC MEETING DISPLAY** (**Summary 1**).

Policy on **PAYMENT OF SPEAKERS' EXPENSES** (**Summary 3**).

SECTION AFFILIATION with Engineering Societies Councils (**Summary 4**).

DECATUR DIVISION of Central Illinois Section (**Summary 5**).

KALAMAZOO VICE CHAIRMAN of Western Michigan Section (**Summary 6**).

Appointment of **PUBLICATION STUDY COMMITTEE** (**Summary 10**).

Procedure for mailing National Meeting Program Information to **OVERSEAS MEMBERS** (**Summary 12**).

Action on members **DELINQUENT IN 1960–61 DUES** (**Summary 11**).

ELECTION of 112 Applicants to Membership (**Summary 12**).

GRADE TRANSFER of 8 members (**Summary 12**).

Establishment of **EXCHANGE SECRETARIAL MEMBERSHIP** with The Royal Aeronautical Society (**Summary 12**).

CONFIRMED

PRESIDENTIAL APPOINTMENTS (**Summary 7**).

J. M. Campbell on Advisory Board of the Office of Critical Tables of National Academy of Sciences.

Leonard Raymond as SAE Representative on the Elmer A. Sperry Board of Award.

REJECTED

New York Institute of Technology as a school for **SAE ENROLLED STUDENTS** (**Summary 12**).

Nineteen applicants for **MEMBERSHIP** (**Summary 12**).

TRANSFER IN GRADE of one member (**Summary 12**).

(1) New York Aeronautic Meeting Display Discontinued

At the recommendation of the Engineering Activity Board, the Board of Directors approved of the discontinuance of the engineering display held in conjunction with the Aeronautic Meeting in New York City in April. It was understood that the advisability of re-establishing the display would be carefully considered periodically and that it would again be scheduled when such action appears to be desirable.

(2) Proposed Policy for Cooperation between the SAE and Other Groups

The Board of Directors considered a proposed policy for cooperation between the SAE and other engineering societies and technical groups. It was the sense of the Directors that this proposed policy should be given careful study before action is taken; it was therefore, voted to submit the proposal to the Directors for mail ballot.

(3) Policy on Payment of Speakers' Expenses

Acting on the recommendation of the Engineering Activity Board, the Board of Directors approved of the following policy on payment of speakers' travel expenses:

> "SAE policy is that travel expenses for National Meeting speakers shall not be paid by the Society. It is recognized that there may be cause for exception of this policy, in which case such requests are to be submitted to the EAB before any commitment is made or the program finalized. The request must show that the participant is indispensable to the meeting program and that he is unable to arrange for payment of travel expense from any other source."

(4) Section Affiliation with Engineering Societies Councils Continued

The Board of Directors approved of extending its authorization to the

"A summary report of the actions of the Board of Directors shall be published in the next following issue of the official publication of the Society."
. . . from C 6 of the SAE Constitution

following Sections to continue the indicated affiliations for another year:

- Baltimore Section with Engineers Club of Baltimore
- Cincinnati Section with Engineering Society of Cincinnati and Scientific and Technical Societies Council of Cincinnati
- Cleveland Section with Cleveland Technical Societies Council
- Detroit Section with the Engineering Society of Detroit and Toledo Technical Societies Council
- Northern California Section with Santa Clara Valley Engineers' Council
- Philadelphia Section with Engineer's Club of Philadelphia

In addition, the Directors approved of the request from the Syracuse Section to affiliate with the Technical Societies Council of Greater Syracuse.

(5)

Central Illinois Section Division in Decatur Established

The establishment of a division of the Central Illinois Section in Decatur, Illinois, was approved.

(6)

Kalamazoo Vice Chairman Added to Western Michigan Section Officers

Upon recommendation of the Sections Board, the Board of Directors authorized the Western Michigan Section to add the post of Regional Vice Chairman representing the Kalamazoo area to its officers.

(7)

Presidential Appointments

The Directors confirmed President Kucher's appointment of the following:

(a) J. M. Campbell, Scientific Director, General Motors Corporation, nominated as representative on the Advisory Board of the Office of Critical Tables of the National Academy of Sciences, National Research Council, July 1, 1961, to June 30, 1964.

(b) Leonard Raymond, Chief Automotive Engineer — Research, Socony Mobil Oil Co., Inc., as SAE representative on the Elmer A. Sperry Board of Award for a term of four years, beginning January 1, 1962.

(8)

1961 L. Ray Buckendale Lecture

The Board of Directors accepted the report of the 1961 L. Ray Buckendale Lecture Committee indicating that Mr. Wells Coleman of the Gleason Works had been selected to present the 1961 Buckendale Lecture and that the subject of the lecture will be "The Design and Manufacture of Heavy Duty Drive Gears."

(9)

Russell S. Springer Award

For the first time since its establishment in 1954, the annual Russell S. Springer Award will not be made because no author fits the requirements laid down by the rules.

This award is presented annually to the youngest SAE member whose paper is published in SAE Transactions in the year in which the award is made. According to the rules of the award, the author must be thirty-three years of age or younger. In addition, authors of papers written by three or more co-authors cannot be considered eligible.

The Directors expressed keen disappointment that there was no Springer Award recipient for 1961 and suggested that consideration be given to encouraging the presentation of papers by young authors in the age group eligible for this award.

(10)

Study of SAE Publication Policy and Procedures

As a result of recommendations developed at the Publications Conference held in St. Louis, the Board of Directors authorized the SAE President to appoint a Publication Study Committee to study publication problems and procedures across the Society as a whole — problems involving the Engineering Activity Board, the Technical Board, the Sections Board and the Publication Committee.

(11)

Action on Members Delinquent in 1960-61 Dues

The Board of Directors voted that all 1960–61 dues outstanding as of September 30, 1961, be written off the books of account and that members owing all or part of these dues be handled in the following manner.

1. Former Section, Group, or Society officers and those members who have paid dues for 20 or more years be resigned in good standing.

2. Members residing overseas be resigned in good standing (because of devaluation of currencies and difficulties in obtaining U. S. Dollars in many countries.)

3. Members in the U. S. Military Services; those who are delinquent in dues because of illness or finances; and current or past SAE Student Branch Faculty Advisors, be transferred to Reserve Member Status.

4. All delinquent members not included in the above categories be removed from the rolls of membership and advised of this action.

The Directors also voted that members whose matured notes remain unpaid on September 30, 1961, be dropped from the rolls of membership and that the total amount of their outstanding notes be written off the books of account.

(12)

Other Actions of the Board of Directors

- Approval of proposed procedures for mailing National Meeting Program information to SAE members overseas;
- Acceptance of Finance Committee report on Society's income and investments and the Financial Statement as at April 30, 1961;
- Election of 112 applicants to membership in the Society, approval of transfer of grade of 8 members, denial of membership to 19 applicants and denial of the transfer of grade of 1 member;
- Denial of recognition of the New York Institute of Technology as a school from which the Society may accept engineering students as SAE Enrolled Students;
- Approval of establishing Exchange Secretarial Membership with The Royal Aeronautical Society, London, England.

New Services Launched Out of EAB Plans

J. T. Dyment, 1961 chairman Engineering Activity Board

SAE OVERSEAS MEMBERS will start this Fall to receive advance meeting information . . . the International Information Committee is expanding its personnel to include several additional foreign countries . . . the new Engineering Education Activity Committee is setting in motion the program launched at its first meeting on June 7 — Engineering Activity Board Chairman J. T. Dyment announced, following Board of Directors approval of EAB's recommendations at Summer Meeting.

Keeping Overseas Members Posted

By a first-class direct surface mailing of a checklist containing session, paper, and hotel information, most of SAE's 1100 overseas members will receive program information about six weeks prior to the meeting. Addition of hotel names and addresses Chairman Dyment said, will give those who wish to attend the meeting opportunity to make advance reservations.

IIC Expands for Action

In tune with the times, the International Information Committee is expanding its membership to include representatives from several additional overseas countries. The new setup will consist of two member groups — one domestic and one overseas — operating in close liaison to bring SAE members the newest and best in overseas engineering developments.

EEAC Rounds out Membership

Out of the first meeting of the new Engineering Education Activity Committee held on June 7 came the decision that three types of programs would be planned for presentation at SAE National Meetings:

1. Trends toward increased science in engineering. (Plans for a session on this subject are already under way for the 1962 Automotive Engineering Congress in January.)
2. Obsolescence of manpower.
3. Highlighting technical sessions of particular interest to university people.

J. J. Mikita of du Pont is chairman of the Committee and Dean K. F. Wendt of University of Wisconsin is co-chairman. Serving with them as committee members are Lamont Eltinge, American Oil Co.; J. E. Goldman, Ford Motor Co.; W. S. Hill, General Electric Co.; P. R. Kyropoulos, General Motors Corp.; D. R. Olson, Yale University; W. T. Olson, National Aeronautics and Space Administration; F. H. Roever, McDonnell Aircraft Corp.; Marion Smith, Ohio State University; Ernest Starkman, University of California; G. J. Van Wylen, University of Michigan.

NOMINEES FOR 1962 SAE BOARD OF DIRECTORS

President ..... **FRANK W. FINK**
Vice-President Engineering-Products, Ryan Aeronautical Co.

Treasurer ..... **G. A. DELANEY**
Detroit, Michigan

DIRECTORS

Three-Year Term (1962-63-64)

H. L. BROCK
Director of Engineering Research, John Deere Research and Engineering Center, Deere Manufacturing Co.

G. J. HUEBNER, JR.
Executive Engineer, Research, Chrysler Corp., Engrg. Div.; and President, Chrysler Institute of Engineering

F. L. JARRETT
Senior Staff Engineer, FMC Corp., Ordnance Div.

E. P. LAMB
Executive Engineer, Administration, Chrysler Corp., Engineering Div.

J. G. MOXEY, JR.
Assistant Director, Research and Development Div., Research and Engineering Dept., Sun Oil Co.

W. G. NOSTRAND
Executive Vice-President, Winslow Engineering and Manufacturing Co.

M. M. ROENSCH
Assistant Chief Engineer, Chevrolet Motor Div., General Motors Corp.

If elected, the above members will serve on the 1962 SAE Board of Directors

★ ★ ★

Continuing on the Board of Directors will be:

Two-Year Term (1962-63) — (Elected as Directors for 1961-62-63)

P. F. ALLMENDINGER
Director of Engineering, Electrical Products Div., Electric Autolite Co.

J. H. DUNN
Manager, Alcoa Process Development Laboratories, Aluminum Co. of America

J. T. DYMENT
Chief Engineer, Trans-Canada Air Lines, Engineering Dept.

H. L. HIBBARD
Senior Vice-President, Lockheed-California Co.

O. K. KELLEY
Technical Assistant to General Manager, Defense Systems Div., General Motors Corp.

R. C. NORRIE
General Manager, Kenworth Motor Truck Co., Div. of Pacific Car & Foundry Co.

T. L. SWANSEN
Vice-President, Ladish Co.

One-Year Term (1962) — (Elected as Directors for 1961-62)

W. F. FORD
Assistant Director, Petroleum Products Div., Research and Development Dept., Continental Oil Co.

M. L. FREY
Assistant to General Works Manager, Tractor Manufacturing, Allis-Chalmers Manufacturing Co.

M. F. GARWOOD
Chief Engineer — Materials, Chrysler Corp., Engineering Div.

M. J. KITTLER
Executive Vice-President, Holley Carburetor Co.

E. J. MANGANIELLO
Acting Director, National Aeronautics & Space Administration

F. R. McFARLAND
Executive Assistant Chief Engineer, Buick Motor Div., General Motors Corp.

R. R. ROBINSON
Assistant Director of Research, Caterpillar Tractor Co.

PAST-PRESIDENTS

A. A. KUCHER
Vice-President, Engineering and Research, Ford Motor Co.

H. E. CHESEBROUGH
Vice-President — Director, Quality Control, Chrysler Corp.

Numerical control

. . . stimulates First Annual Machine Tool Conference held by SAE Rockford-Beloit Section

ROGER DeLONG chairmanned panel discussion on Economics of Machine Tool and Assembly Machine Purchasing. DeLong is vice-president and assistant general manager of Twin Disc Clutch Co.

GUEST SPEAKER at the Conference dinner was Henry Sandrock, regional manager in charge of Chevrolet manufacturing plants at Flint, Saginaw, and Bay City, Michigan. Discussing "Challenges of the '60's," Sandrock covered Chevrolet requirements for machine tools.

NUMERICAL CONTROL provides versatility and reduces the lead time needed before production can commence, engineers revealed at the First Annual Machine Tool Conference held by SAE Rockford-Beloit Section. Once a drawing is in the hands of the programmer, the part can be placed into production with little additional effort. Drilling and boring jigs which cause delays in manufacture and considerable expense are no longer necessary.

With numerical control, it is no longer the responsibility of the shop to determine the ways in which components will be produced and the types of tools they will use to this end. This now becomes the job of the programmer who, depending upon the organization in which he finds himself, will be responsible either to the engineering department or to the industrial engineering department.

With numerical control, the cutting time of the machine is increased and the handling time is cut down. It is therefore important to recognize that the tool service facilities will have an effect upon the running time of the machine just as with a conventional machine. But, as the cost of a numerical machine is normally greater than the conventional machine tool, this down time has to be cut to a minimum. Therefore, tool grinding and tool preparation facilities have to be upgraded accordingly.

In tabulating the economic advantages of numerical control, we are concerned with the ability of production equipment to change from one task to another. Any economic analysis of proposed low volume production equipment must necessarily determine the dollar value of this job-switching operation as well as the active-machine-time savings. One of the big advantages of numerically controlled machines is that, once a comprehensive library of tapes has been acquired, the machine can be changed from one job to another by threading up the appropriate tape after placing the tool and the work in prescribed initial positions. In some cases, the tool or the work or perhaps both are positioned under tape control.

The cost of producing a tape library must be considered; this cost includes debugging and possibly some pilot runs. If the parts produced are limited in variety, a "canned" or preprogrammed tape library may be sufficient and the whole library may be produced and debugged on the vendor's equipment even before the machine is delivered to the floor. In this case, the tape cost can be dealt with in the same manner as the equipment cost itself. But, if each lot produced on the machine will have a completely different print than all previous lots, a new tape must be prepared and its cost may be balanced against comparative costs for its particular lot.

Plant Tours

Five plant tours were held in conjunction with the First Annual Ma-

chine Tool Conference. SAE'rs visited the plants of Barber-Colman Co., Greenlee Bros. & Co., Ingersoll Milling Machine Co., Mattison Machine Works, and Sundstrand Machine Tool Co.

Conference Dinner

Featured speaker at the Conference dinner was Henry Sandrock, regional manager, Flint-Saginaw-Bay City Plants, Chevrolet Division of GMC. Discussing "Challenges of the '60's", Sandrock spelled out Chevrolet's future requirements for machine tools.

Sandrock revealed that the machine-tool industry must supply tooling which has a high degree of flexibility to permit its full utilization and proper return on investment by the passenger-car industry. Standardization of equipment and interchangeability of tools was suggested as one way to make these goals realizable.

Rockford-Beloit Section

The Rockford-Beloit Section of SAE is an outgrowth of the SAE Chicago and Milwaukee Sections. It was formed last year with 130 members. The first chairman of the new Section was W. C. Arnold of Fairbanks, Morse & Co. The present chairman is John B. Ingold of the Woodward Governor Co.

Officers in the Section this year are Arnold, vice-chairman, Powerplant Activity; Roger Birdsell, Yates-American Machine Co., vice-chairman, Production Activity; Forest C. Hile, Warner Brake & Clutch Co., vice-chairman, Truck and Bus Activity; Edward J. Retzinger, Fairbanks, Morse & Co., secretary; and Hugo F. Budzein, Beloit Iron Works, SAE Journal field editor.

General co-chairmen for the First Annual Machine Tool Conference were Wilson Green of Gilman Engineering & Mfg. Co. and W. C. Arnold of Fairbanks, Morse & Co.

Chairman of the General Industry Committees was John B. Ingold of Woodward Governor Co. Roger Birdsell of Yates-American Machine Co. was responsible for the technical program at the Conference. Plant tours and luncheons were under the direction of U. B. Grannis of Mechanics Universal Joint Division of Borg-Warner Corp. Advance and local publicity was handled by Hugo F. Budzien, Beloit Iron Works.

Dinner arrangements were handled by Roger Miller of Gunite Foundries Corp. Phil Mosher, Sundstrand Aviation Division of Sundstrand Corp., headed up the Display Committee. J. Sturm, Sundstrand Aviation Division of Sundstrand Corp., piloted the Financial Committee. Registration and reservations were handled by Forest C. Hile, Warner Electric Brake & Clutch Co.

Rambling through the Sections

AT THE MAC SHORT AWARD presentation ceremony during **SOUTHERN CALIFORNIA SECTION'S** Ladies Night meeting (left to right) are Prof. A. L. Klein, California Institute of Technology; Bill J. Castenholz, Award winner; Mrs. Mae Short, who made the presentation; and Paul L. Garver, City of Los Angeles Dept. of Public Utilities & Transportation.

PRESENTATIONS were the order of the evening at **SOUTHERN CALIFORNIA SECTION'S** Ladies' Night, when the 1961 Mac Short Award, the SAE Student Branch Charter to California State Polytechnic College at Pomona, and plaques to four faculty advisors were presented.

Principal speaker of the meeting was Los Angeles Metropolitan Transit Authority's Chief Engineer, E. R. Gerlach . . . who told his audience of more than 200 why transportation planning and community planning go hand in hand. His talk was titled "After Freeways — What?"

Mrs. Mae Short presented the Mac Short Award plaque to B. J. Castenholz of California State Polytechnic College at San Luis Obispo, and certificates and pen and pencil sets to the two runners-up, Paul J. Votava, Jr., Northrop Institute of Technology and H. Edward Sturm, California State College at Pomona.

Prof. A. J. Acosta, California Institute of Technology at Pasadena, Prof. Joseph P. Callinan, Loyola University at Los Angeles, Prof. Richard T. Kombrink, California State Polytechnic College at San Luis Obispo, and Prof. Morris Kramer, Northrop Institute of Technology at Inglewood were the four faculty advisors honored by SAE with plaques for their services in advancement of their respective SAE Student Branches.

Ramblings continued on next page

Rambling through the Sections . . . continued

Grumman's John K. Roper (center) spoke before a recent **NORTHERN CALIFORNIA SECTION** meeting on hydrofoil craft . . . starting with the early experimental days, to present usage, and possible future developments for transportation and military applications.

With him are Raymond E. Sickler (left) who arranged the program, and Forest W. Fingerle (right), 1960–61 South Bay Division chairman.

OUTGOING NORTHWEST SECTION Chairman L. W. Schroeder (left) turns over the Section helm to incoming Chairman W. M. Brown (right) at the Section's Annual Ladies Night Meeting.

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AMONG THE "TIPS" ON SPARK PLUG OPERATION, passed on to SALT LAKE CITY GROUP members and guests at its May meeting held at Diesel Electric Service & Supply Co.'s plant, were:

Short circuiting and failure can result from a hardened rubber boot on a spark plug. A corona around the plug, on the other hand, is not detrimental — but the insulator should be kept clean. . . . When the leads to plugs are in parallel position, they can cause "crossfire." To remedy — cross the leads. . . . A dished ground electrode can be an indication of reversed polarity.

A mobile laboratory — fitted with a 5 hp Kohler gasoline engine generating set, and provided by Champion Spark Plug Co. — served to demonstrate the effects of spark plugs with different heat ranges.

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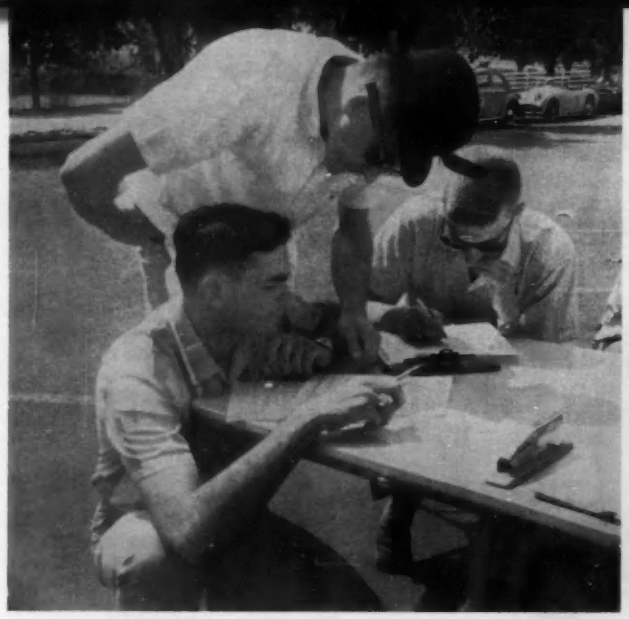
Seated rear (left to right) J. B. Webster, C. S. Finkle, R. J. Twaddle, G. E. Heaton, Les Crichton, W. A. Lovell, and D. R. Thom take time out for refreshment at **ONTARIO SECTION'S** Annual Golf Party.

Gathered on the 18th green at **ONTARIO SECTION'S** Annual Golf Party at Kitchener (left to right) are W. R. Trimble, S. G. Curtis, Bill Willis, Ed Castle, P. B. Mason, Bob Suddard, Andy Yamanaka, and E. M. Bailey.



Contestants plotting strategy after receiving course maps and instructions.

Fueling — supervised by the driver.

Cal-Poly SAE Student Branch (Pomona) stages "economy run"

THE SAE STUDENT BRANCH at **California State Polytechnic College, Kellogg-Voorhis Campus, Pomona,** wound up its first year of activities with an SAE Economy Run, staged jointly with the Pomona Optimist Club.

Rules limited the event to 20 entrants — with cars driven by SAE Student Branch members or their friends. Early planning enabled the students to obtain free gasoline (supplied by Richfield Oil Corp.), free lunch for the contestants, seven engraved trophies for the winners . . . and a pie feed for everyone at the end of the day.

Round-up of the event showed the winners to be:
Sweepstakes: Best mpg — J. R. Cahan — '58 Fiat 600 — 39.70 mpg
Rally Time: 16:00.0 — R. G. Brown — '58 Volkswagen — 15:52.2
Elapsed Time: 2:57:00.0 — J. M. Joy — '56 Chevrolet — 2:57:11.4

Classes:
A: Best ton-mpg — G. E. Homer — '60 Simca Etoile — 40.70 ton-mpg
B: Best ton-mpg — R. S. Coclich — '59 Studebaker Lark — 34.80 ton-mpg
C: Best ton-mpg — M. Robinson — '52 Mercury Mont. — 34.70 ton-mpg
D: Best ton-mpg — G. L. Gates — '41 Chev — GMC 302 — 34.10 ton-mpg

Prof. H. A. Mylander, SAE Student Branch advisor, (left) views with Dean Harold P. Skamser, Engineering Division, California State Polytechnic College (right) seven trophies to be awarded winners in Economy Run.

Prof. H. A. Mylander (center) presents trophies to the winners while a Student Branch committeeman (left) calls them off. All are wearing "crazy hats" stipulated as the order of the day.

The drivers are briefed by Prof. Mylander before start of the race.

LeTourneau and Firestone's Research & Development Division share '61 Sperry Award

ROBERT G. LeTOURNEAU, president, LeTourneau, Inc., and Firestone's Research & Development Division share 1961 Elmer A. Sperry Award honors as pioneers in developing the giant earthmoving equipment that has made possible today's complex transportation system. Presentation of the Award is scheduled at luncheon on Tuesday, Sept. 12, during SAE's National Heavy Duty Vehicle Meeting at the Milwaukee Auditorium, Milwaukee.

Since the early 1920's through World War II, LeTourneau designed and produced more than half the heavy construction equipment used by the U. S. Armed Forces. Among inventions with which he is credited are the first grading machines to use welded frames, and the first to use rubber tires; electric control for scraper wheels; mammoth logging machines to carry 28 tons of logs over rough country; a "jungle destroyer" to crush trees and undergrowth into a mat-like carpet; and special military vehicles capable of picking up stranded landing craft or disabled bombers and carrying them to safety in minutes. LeTourneau has been an SAE member since 1949.

Developments pioneered by the Firestone organization are credited with freeing earthmoving equipment from the metal wheels which once limited their effectiveness.

Robert G. LeTourneau

Administered by five engineering societies, the Elmer A. Sperry Award is made for a distinguished engineering contribution proved through actual service to have advanced the art of transportation, whether by land, sea, or air. R. W. Trowbridge, SAE's representative, is vice-chairman of the Board of Award.

Engineers or Scientists?

WITH THE CRY for more qualified scientists still ringing throughout the nation, some industry folks are beginning to worry about the supply of qualified engineers. Trends in the engineering schools, some say, are orienting students so strongly toward theory that not enough are being trained to see application of principles as a goal. And some educators agree. "We're graduating whole classes of boys," one veteran SAE faculty advisor said recently, "who don't — and can't at graduation — even *think* like an engineer has to think."

Some public horn-locking on this issue is planned at the 1962 SAE Automotive Engineering Congress at Detroit's Cobo Hall next January. SAE's newly formed Engineering Education Activity Committee will sponsor the argument via a session on the significance to industry of current educational trends.

'61 Mac Short Award Goes to B. J. Castenholz

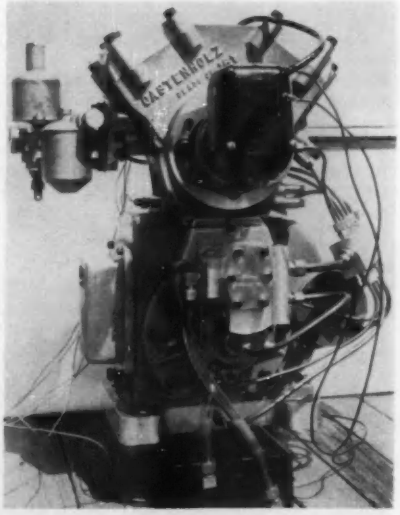
BILL J. Castenholz, California State Polytechnic College at San Luis Obispo, won first prize in the 1961 Mac Short Award Contest with his paper on "Design, Construction, and Preliminary Testing of a Single-Cylinder Internal Combustion Engine."

It took Castenholz some 1400 hr to complete this test engine which the paper describes. Designed for use in testing "a variety of components," the engine has a single cylinder, a 4-stroke cycle, and is of the reciprocating internal combustion type. In carrying out the project, Castenholz converted a few of the engine components from other uses, or purchased them as ready-made items (crankcase, connecting rod, and piston). He made original designs for all other components.

Some of the engine components which are not variable are unusual, and they will be continually observed to study their characteristics. The spark plug is recessed from the combustion chamber, and connected to the chamber by a small opening. The cylinder liner, while removable, has a fixed method of attachment which shows possibilities for low cost replacements and low temperature distortion. The oil system has the unusual task of lubricating and cooling of both journal and antifriction bearings in the same crankcase. Sprayers which atomize the oil and cool the ball bearings at high speeds have operated successfully.

Thorough instrumentation assures that all critical data necessary to evaluate various tests will be available. Thermocouples were located in many places in the water jacket and oil sump to readily indicate overheating, and to study temperature distribution in the water.

Runners up in the contest staged annually by Southern California Section were Paul J. Votava, Jr., Northrop Institute of Technology for his paper "Investigation of Automobile Engine Oil Drain Periods"; and H. Edward Sturm, California State Polytechnic College, Voorhis Campus, for "Theoretical Considerations and Experimental Verification of the Levapad Concept."



Single cylinder internal combustion engine designed by B. J. Castenholz

YOU'LL . . .

. . . be interested to know . . .

TO ENCOURAGE suitable cooperation between agencies of SAE's Engineering Activity Board and other engineering societies and technical groups, EAB has clarified its policies through which such cooperative ventures may properly be undertaken:

Informal liaisons with closely related non-SAE organizations (such as the American Society of Body Engineers, American Society of Lubrication Engineers, etc.) may be established by an SAE Engineering Activity Committee on an informal basis when such action "will foster development, collection, and distribution of technical information of value to SAE members."

Joint planning of technical sessions at national meetings with closely related non-SAE groups may be undertaken by an SAE Activity Committe when invitation to the closely related group to assist in development of technical programs "will provide information of value to SAE members." **Cosponsored meetings,** however, may be arranged with a related technical group only AFTER determination by the EAB that such cosponsorship will be in the best interests of SAE.

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WHILE PLANNING FOR 1962 SAE Automotive Engineering Congress and Exposition, some interesting attendance statistics came to light about the 1961 event . . . from the where-did-they-come-from standpoint.

The 25,511 registrants at the 1961 Automotive Engineering Congress came from 50 states and 23 foreign countries, broken down areawise as follows:

New England	153
Middle Atlantic	832
South Atlantic	109
North Central	18,081
South Central	196
Mountain	27
Pacific	245
Foreign	541
Unclassified	5,327
Total	25,511

A further breakdown of attendance from the closest-to-congress states showed:

Michigan	
Detroit	6,468
Dearborn	1,783
Warren	2,959
Flint	441
Grand Rapids	14
Lansing	44
Misc.	1,501
Ohio	
Cleveland	230
Akron	65
Columbus	12
Cincinnati	20
Toledo	317
Misc.	350
Illinois	
Chicago	343
Peoria	49
Misc.	192

FACTS . . .

. . . from SAE literature

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.)

ENGINEERING CONSULTANTS — 34 pages of them — are listed in the booklet titled "SAE Consultants" compiled by SAE Placement Service. Names, addresses, 'phone numbers, fields of specialty, and territories of operation are provided.

●

EVERY PIECE OF FARM AND EARTHMOVING EQUIPMENT — such as brakes, lighting components, engines, transmissions, crankcase oils, tires and wheels, accessory and mounted equipment, fasteners, and metallic and nonmetallic material — has SAE content. The booklet titled "How CEP Serves the Earthmoving and Farm Equipment Industries" gives the specifics.

●

INCREASED USE OF ALUMINUM in castings for engine blocks, transmission cases, differential carriers, etc., prompted preparation of the pamphlet "How the SAE Cooperative Engineering Program Serves the Aluminum Industry."

●

ILLUMINATING ALL THAT IS NEW in automation, engineering processes, technical standards, and research development — SAE publications and meetings open up new horizons for the air transport man. (From the booklet "SAE Air Transport" prepared by SAE Activities Membership Committee.)

●

REPEAT PARTICIPATION in SAE's 1962 Automotive Engineering Exposition in Detroit's Cobo Hall in January, is expected by 90% of last year's exhibitors. . . . And requests for space from 75 new companies point to a considerably expanded 1962 Exposition. (From the booklet "SAE 1962 Automotive Engineering Exposition."

SAE Section Meetings

ATLANTA

September 11 . . . "Technical Refinements of Production Cars for Stock Car Racing." Yohannan's Restaurant. Social hour 6:30; dinner 7:00, meeting 8:00 p.m.

BALTIMORE

September 21 . . . E. Vincent Hoddinott, acting assistant commissioner, Department of Transit & Traffic, City of Baltimore. "Modern Traffic Control Devices." Meeting place: Department of Transit & Traffic, Baltimore, Md. Dinner 6:30; meeting 8:00. Special Feature: Inspection Tour of Electronic Traffic Control Center.

FORT WAYNE

September 13 . . . Plant Tour of Phelps Dodge Copper Prod. Corp., Fort Wayne, Ind.

MID-MICHIGAN

September 25 . . . Dr. B. P. Blasingame, director of engineering, AC Spark Plug Division, GMC, Milwaukee, Wis. "Space Trend — Sense or Nonsense." Hotel Durant, Flint, Mich. Dinner 6:30; meeting 8:00 p.m.

SYRACUSE

September 12 . . . Len Segal, engineer, Cornell Aero Laboratory. "Automobile Safety." John Milton Motel, Thompson Rd. & Thruway. Dinner 6:45; meeting 8:00.

TWIN CITY

September 13 . . . Hasty Tasty Restaurant, Minneapolis. Social hour 6:15; dinner 7:00 p.m.

●

SAE MEMBERS

SAE PAST-PRESIDENT H. E. CHESEBROUGH, Chrysler Corp. vice-president, has been named director of quality control. In this capacity, he will coordinate the corporation's quality assurance activities in the engineering, manufacturing, purchasing, and inspection and testing departments. He had been general manager of Chrysler's Plymouth Division.

E. M. DeWINDT has been named president of the newly created International Division of Eaton Mfg. Co. This division will consolidate the company's foreign activities. DeWindt is also vice-president of the corporation.

Chesebrough

Wallace

DeWindt

McDougall

ROBERT C. WALLACE is now assistant chief engineer of the White Division of The White Motor Co. He reports directly to **E. R. STERNBERG,** chief engineer of the White Division. (On p. 119 of the July issue, SAE Journal **incorrectly** stated that Wallace was chief engineer.) Previously, Wallace was director of engineering of White's Diamond T Division. He is a past SAE Director and currently is active as a member of the SAE Truck & Bus Activity Committee. He is also a past chairman of SAE Chicago Section.

JOHN McDOUGALL has been made director of Ford Motor Co.'s manufacturing engineering and development office. Previously he was manager of the materials and equipment department.

MELVIN P. HERSHEY has been appointed manager of tire engineering, Firestone Tire & Rubber Co. Prior to this appointment he was manager of engineering for passenger, racing and airplane tires.

A. C. SAMPIETRO has been named chief engineer at Willys Motors, Inc. He has most recently been a consultant to Willys and several other firms both in the United States and Europe.

Hershey

Sampietro

Seeler

Witzky

J. H. FAMME has been named vice-president of operations for General Dynamics-San Diego. He has been associated with Convair for a number of years, most recently as manager of the Division's manufacturing development. Famme is a past SAE Director, a Past Chairman of the San Diego Section, and currently continues as a member of the Aerospacecraft Activity Committee of the SAE Engineering Activity Board and of the Aerospace Council of the SAE Technical Board.

GORDON C. SEELER has been named head of the Additives Section at the Enjay Laboratories, a division of Humble Oil & Refining Co. He was previously marketing coordinator for the Enjay Chemical Co.'s Paramins Division.

RAYMOND HAMADA former vice-president of Telecomputing Corp. and general manager of its Whitaker Controls Division, has joined Houston Fearless Corp. as senior vice-president, operations.

RUDOLF HOSS has been appointed general manager of a new subsidiary established in Germany by Purolator Products, Inc. The subsidiary will provide sales and service facilities for the complete line of filters and replacement elements manufactured by Purolator Products, Inc.

LOUIS B. ZAMBON has been appointed vice-president — engineering, Pratt & Whitney Co., Inc. He was previously manager of engineering, Flight Propulsion Division, Large Jet Engine Department, General Electric Co.

JULIUS E. WITZKY, developer of the Mercedes 180D diesel and former chief engineer and head of the Diesel Engine Division of Damiler-Benz A. G., has joined Designers for Industry as a special consultant.

GEORGE N. JENKINS, assistant manager of sales engineering for the Esso Standard Region, Humble Oil & Refining Co., has been named coordinator of sales engineering in the new headquarters marketing department of the Humble Co. in Houston, Texas.

Active in SAE, Jenkins has served as program chairman and as vice-chairman for fuels and lubricants activities in Metropolitan Section.

JOSEPH E. STANLEY has been named sales manager for the Aircraft/Electronic Controls Division of General Controls Co. Until his appointment to the General Controls sales staff, Stanley was with Wells Industries of North Hollywood.

HAROLD E. FRANCIS has been appointed sales manager for nuclear and industrial products at Chandler Evans Corp. He has been market research manager for the company during the past year and prior to that its chief engineer for commercial products.

ARTHUR F. OCHTMAN has retired as manager of engine engineering at the Harvey, (Ill.) Works of Allis-Chalmers Mfg. Co. His retirement ends 44 years of association in the gasoline and diesel engine industry.

Previously manager of engineering of the Engine Division of the former Buda Co., he became affiliated with Allis-Chalmers when it acquired Buda in 1953.

WALLACE W. WITHEE, formerly senior assistant chief engineer in the Astronautics Division, General Dynamics Corp., has been named vice-president — research and enigineering.

This position is one of three new ones resulting from the recent designation of Astronautics as a full division, concerned with space programs. Withee has been working on the Atlas program since 1954.

JOSEPH A. DOYLE has been elected vice-president and director of marketing — military of Howell Instruments, Inc. Formerly he was special assistant to company president **JOHN S. HOWELL.**

Doyle is a colonel in the Air Force.

GEORGE RANSOM has been named administrative engineer, Power Development Division, GMC. He was formerly section engineer. **RALPH SCHWIND** has been named section engineer.

FRANCIS J. BOROWSKY has been elected president of the George K. Garrett Co., Inc. He was previously executive vice-president.

CHARLES A. BIENENSTEIN, formerly a designer with Chrysler Corp., has joined Delta Welder Corp. as a design checker.

Zollner Promotes Two

Cormany

Johnson

GENE A. CORMANY has been named vice-president in charge of engineering of Zollner Corp. and **C. EDWARD JOHNSON** has been named executive engineer. The announcement is made by **FRED ZOLLNER,** president of the corporation.

CORMANY has been in charge of Zollner's engineering staff as executive engineer since 1957, with responsibility for research, design, and development of pistons — and for coordination of these functions with engine manufacturers. As vice-president, he will retain control of these functions, but will devote more time to engineering policy and planning. His professional career has brought him extensive experience in development of high-output engines. He was graduated from Kansas University in 1940 with a B.S. in mechanical engineering.

JOHNSON, who has worked with Zollner since 1935, was design engineer before taking his new position as executive engineer.

DONALD G. HARTER has been elected vice-president — research and engineering, of Kodiak, Inc. Prior to joining Kodiak he was director of engineering for the York Division of Borg-Warner Corp.

Harter, who holds a number of patents in the refrigeration field and has written papers on refrigeration and automotive air conditioning, will be responsible for research, development, and production engineering on all Kodiak automatic cube and flake ice machines.

DONALD W. BEHRENS has been appointed western district manager of the Fuller Transmission and Unit Drop Forge Divisions of Eaton Mfg. Co. and Shuler Axle Co., an Eaton subsidiary. He was formerly assistant manager.

Behrens succeeds **E. L. KING** who retired in June, after 32 years with the company.

JAMES N. SOWERS has been elected assistant controller for American Airlines, Inc. In this position he will be responsible for providing methods, engineered standards, general industrial engineering assistance, and procedure services on a companywide basis. Sowers was formerly director of methods and standards.

H. DOUGLAS LOWREY has been made general manager of the Defense Operations Division of Chrysler Corp. The division has research, development and manufacturing facilities in Center Line, Mich., Newark, Delaware and Scranton, Pa. Lowrey was previously assistant general manager of the Missile Division.

ROBERT E. BARNUM has been appointed technical service coordinator of the Paramins Division of Enjay Chemical Co., a division of Humble Oil & Refining Co. He joined the company in June after 14 years with Esso Research & Engineering Co.

Barnum replaces **WILLIAM B. HUNGERFORD,** who transferred recently to the Project Development Division as a planning coordinator.

Barnum

Hungerford

Jenkins

Stanley

Francis

Ochtman

MANY SAE MEMBERS participated in the ceremonies opening Sealed Power Corp.'s new Research and Engineering Center at Muskegon, Mich., last month. Among them (left to right) were these Sealed Power executives: D. M. Hesling, vice-president, research and engineering; D. A. Paull, chief metallurgist; R. E. Murbarger, vice-president, sales; P. C. Johnson, president; and G. E. Reynolds, vice-president, manufacturing. . . . Opening of the new 42,000-sq ft facility was an important event in the celebration by Sealed Power of its Golden Anniversary.

ELMER D. SOWERS is now associated with Chicago Express, Inc., where he is vice-president — maintenance. He was formerly with Consolidated Freightways, Inc., where he served as shop manager.

DONALD BLANCHARD, SAE headquarters staff engineer, and **C. W. JACKMAN** of Chevrolet returned recently from Geneva, Switzerland, where they participated as United States delegates in the 11th session of the Working Party on the Construction of Vehicles of the Subcommittee on Road Transport of the Inland Transport Committee of the United Nations Economic Commission for Europe. The Working Party consisted of motor vehicle officials representing various European countries. They were gathered to work on development of uniformity of European practice in connection with technical and legal requirements for motor vehicles and their equipment.

ROGER F. MATHER has joined Mine Safety Appliances Co. of Pittsburgh as director of research and engineering. For a number of years previously he was with U. S. Steel's product development department as project manager. Mather has been a member of the SAE Engineering Materials Activity Committee and active in the Pittsburgh Section.

THOMAS H. TERRY has been named chief brake engineer of the Axle Division of Eaton Mfg. Co. Terry was formerly associated with Raybestos-Manhattan, Inc. as Cleveland district sales manager.

STEPHEN KALMAR, executive assistant engineer-in-charge at the Power Development Division of General Motors Corp., has retired after nearly 36 years of service with the corporation.

JOHN R. HARRIS, fleet superintendant for Richmond Newspapers, Inc., retired in February after 31 years. An active member of SAE, Harris has been a Section delegate to the National Nominating Committee.

ANTHONY E. COCOROS is now manager of projects of the Atomic Fuel Department, Westinghouse Electric Corp. He was formerly assistant manufacturing manager of the Aviation Gas Turbine Division.

Cocoros has been active in Kansas City Section as publicity chairman, vice-chairman, and most recently chairman. He was attendance promotion chairman for the National Aeronautic Meetings in New York and Los Angeles in 1960.

EARL HOBEIN has been named product representative in the San Diego, California and Arizona area for Parker Seal Co., a division of Parker-Hannifin Corp. He was previously head of Eastern manufacturing for Parker Seal Co. in Lexington, Ky.

ROBERT M. WORTH has been named original equipment account executive for the Electric Autolite Co. In his new post he will be in charge of the company's sales relations with International Harvester Co., White Motor Co. and Checker Cab Mfg. Corp.

AMOS E. NEYHART, administrative head of the Institute of Public Safety in Continuing Education at Pennsylvania State University, has been invited by the government of Yugoslavia to assist in the establishment of 19 training centers in the field of traffic. His three-month visit started this month.

PHILIP WEISS, head of Polymers Department, GMC, was the organizer of an international symposium on adhesion and cohesion at General Motors Research Laboratories July 24–25. Fourteen papers were presented to 125 scientists. Representatives from Belgium, Great Britain, The Netherlands, West Germany, Austria, Japan, Canada, Italy, and India were present.

RICHARD D. KELLY is the new manager of national account sales for the Electric Autolite Co. Formerly he was account executive supervising sales to vehicle manufacturers. Prior to that he directed battery original equipment sales.

JOHN WALKER has been appointed product manager — sales, for Mack Trucks, Inc. He was previously manager of sales engineering.

Leece-Neville Appointments

HAROLD J. ZUSKE and **ALBERT D. GILCHRIST** have been appointed to newly created vice-presidential positions at the Leece-Neville Co. **ZUSKE** is vice-president and general manager of the Fractional Horsepower Motor Division. **GILCHRIST** is vice-president and general manager of the Alternator and Standard Products Division. He is a member of the SAE Sections Board. **ROBERT G. HILL,** former sales manager, has been named general sales manager.

Zuske

Gilchrist

Hill

LEROY R. GRUMMAN, Chairman of the Board of Directors and one of the founders of Grumman Aircraft Engineering Corp. was awarded an honorary Doctor of Laws degree at the 65th annual commencement exercises of Adelphi College.

J. B. GATES, previously general sales manager, has been appointed to the newly created position of director of sales and marketing for Thompson Products Michigan Division of Thompson Ramo Wooldridge, Inc.

ALLEN K. PARRISH will succeed Gates as general sales manager of the Michigan Division. He was formerly assistant general sales manager for the division.

ALFRED P. SLOAN, JR., honorary chairman of General Motors Board of Directors, recently became the first recipient of the National Automobile Dealers Association's "Order of the Golden Wheel." The award, established last year by the NADA Board of Directors to honor outstanding individuals in the automotive world, was presentated to Sloan during a reception in his honor at The Waldorf-Astoria Hotel.

TRANT JARMAN has been made Midwestern sales representative of "Car and Driver," formerly "Sports Cars Illustrated." Prior to joining "Car and Driver," Jarman was an engineer with the Chrysler Corp.

His experience with automobiles includes racing, designing, building, and testing.

W. H. McKENZIE, manager of engineered auto products sales for Goodyear Tire & Rubber Co., was honored at a special ceremony after 45 years of service.

ROY C. INGERSOLL, chairman of the Board of Borg-Warner Corp., has been named chairman of the Automotive Parts Division of the 1961 Commerce and Industry Campaign for Project HOPE.

Project HOPE is the organization which has sent the American floating medical teaching-training center, the S. S. HOPE I, to Southeast Asia.

Ingersoll will be responsible for raising funds through the automotive parts firms throughout the nation to help HOPE continue to aid newly developing nations.

GIOVANNI BONMARTINI is the author of a recently published book, "The Wheel: Roads = The Track: Natural Soils." The book gives a condensed description of the studies and research carried out in order to obtain a high speed pneumatic track consisting of one continuous band.

The book is published by the author, Via S. Teodoro, 2 — Roma.

MURRAY K. SIMKINS is the new editorial director of "Eastern Truck News," and will be in charge of their new Detroit quarters. He was formerly executive editor of "Commercial Car Journal."

Two SAE members, **THOMAS E. EGAN** and **JAMES H. LANSING,** were among 17 leaders in the field of engineering materials who were honored by the American Society for Testing Materials for outstanding service to the society. The Awards of Merit were received at a luncheon during the 64th annual meeting of the society in Atlantic City.

EAGAN, chief research metallurgist, the Cooper Bessemer Corp., was recognized for outstanding contributions to the field of ferrous metals; **LANSING,** executive secretary, Ductile Iron Society, Cleveland, for long and devoted participation in the field of cast metals.

JEROME LEDERER managing director of the Flight Safety Foundation, Inc. spoke at the 17th annual meeting of the Institute of Navigation. The subject of the industry-government panel discussion was "A New Look in Air Navigation and Traffic Control."

ARTHUR W. GARLIEB, JR. has been appointed assistant regional manager of the Commercial Sales Division, American Bosch Arma Corp. Formerly he was district sales manager.

Obituaries

JOHN M. LESSELLS . . . (M'30) . . . president, Lessells & Associates, Inc. . . . died May 17 . . . born 1888.

A. J. PARSONS . . . (M'53) . . . owner, A. J. Parsons Willys Sales and Service of Washington, Pa. . . . member Pittsburgh Section Governing Board for past three years . . . died July 11 . . . born 1906.

W. I. SHIPP . . . (A'51) . . . Eubank — White Truck Corp. . . . died May 27 . . . born 1916.

ADAM F. SMITH . . . (A'33) . . . president, R. C. Smith & Son Ltd. . . . died February 20 . . . born 1884.

GEORGE C. STEVENS . . . (M'28) . . . retired; formerly Chicago branch manager, Diamond T Motor Car Co. . . . died May 24 . . . born 1887.

HILAND G. BATCHELLER . . . (M'48) . . . chairman of the board, Allegheny Ludlum Steel Corp. . . . died May 19 . . . born 1885.

BASIL G. BENTZ . . . (M'55) . . . co-owner, B — K Mach Co. . . . died May 18 . . . born 1906.

FREDERICK CHARAVAY . . . (M'08) . . . retired; formerly consultant engineer, Hartzell's Industries Inc. . . . died February 9 . . . born 1886.

WM. FROHMAN KUPFERSCHMID . . . (M'39) . . . section engineer, Electric Auto-Lite Co. . . . died October 11 . . . born 1898.

HUGO C. LANGE . . . (M'51) . . . manager, Midwest division, Trailmobile, Inc. . . . died June 20 . . . born 1904.

Among SAE Enrolled Students

. . . who have entered industry

MELVIN L. AARANSON . . . Pennsylvania Military College . . . cadet engineer, Station Economy Division, Philadelphia Electric Co.

OSCAR W. ABEL . . . Chrysler Institute of Engineering . . . car air conditioning test and development engineer, Engineering Division, Chrysler Corp.

ROBERT ABERBACH . . . Manhattan College . . . installation and service engineer trainee, General Electric Co.

HAROLD J. ADAMS . . . Academy of Aeronautics . . . engineering clerk, Marine Division, Sperry Gyroscope Co.

FREDRIC C. ALDRICH . . . Michigan State University . . . project engineer, Oldsmobile Division, GMC.

HARRY W. ALLEN . . . University of Washington . . . plant staff assistant, Pacific Northwest Bell Telephone Co.

ROBERT G. ALTES . . . California State Polytechnic College . . . mechanical design, Lawrence Radiation Laboratory.

DAVE K. ANAND . . . George Washington University . . . design engineer, Carrier Howe Air Conditioning.

BRUCE R. ARMSTRONG . . . Queen's University . . . engineer, Canadian International Paper Co.

DAVID G. ASHLAND . . . Lawrence Institute of Technology . . . Ex-Cell-O Corp.

MARK AURIANA . . . Manhattan College . . . engineer trainee, Burndy Co.

MARVIN BAKER . . . Missouri School of Mines and Metallurgy . . . graduate trainee, Chevrolet Motor Division, GMC.

DOUGLAS BARNA . . . Tri-State College . . . test engineer, Goodyear Aircraft Corp.

continued

Among SAE Enrolled Students

. . . who have entered industry (continued)

JAMES R. BARRETT . . . University of Detroit . . . materials engineer, Aviation Products Division, B. F. Goodrich Co.

GEORGE C. BATESON . . . Northrop Institute of Technology . . . sales engineer, Premmco, Inc.

DON M. BATEY . . . Agricultural and Mechanical College of Texas . . . staff assistant, Southwestern Bell Telephone Co.

R. L. BATTERSLY . . . Northrop Institute of Technology . . . quality control engineer, Convair Division, General Dynamics Corp.

GREG F. BENJOCK . . . University of Pittsburgh . . . mechanical engineer, Scintilla Division, Bendix Corp.

DAVID G. BILLES . . . University of Toronto . . . quality control department, Canadian Tire Corp.

RALPH N. BINKLEY . . . Indiana Technical College . . . International Business Machines Corp.

LARRY O. BISCHOF . . . General Motors Institute . . . drafting and layout, Fisher Body Division, GMC.

RICHARD BLAISDELL . . . California State Polytechnic College . . . welding engineer, Mare Island Naval Shipyard.

STANTON BLUMENTHAL . . . Tri-State College . . . mechanical engineer, Missile and Space Vehicle Department, General Electric Co.

RICHARD BOCCHICCHIO . . . The City College . . . associate engineer, American Bosch Arma Corp.

JOHN F. BOOKER . . . Cornell University, Ph.D. . . . assistant professor, Cornell University.

EDWARD W. BREMKE, JR. . . . General Motors Institute . . . Brown-Lipe-Chapin Division, GMC.

H. RAYMOND BROWN . . . Seattle University . . . mechanical engineer, Boeing Airplane Co.

JERRY C. BROWN . . . University of Oklahoma . . . junior design engineer, Food Machinery and Chemical Corp.

ROBERT C. BROWN . . . Drexel Institute of Technology . . . managerial representative, Maleson Co.

M. REAL BRUNET . . . Ecole Polytechnique . . . service engineer, John Deere, Ltd.

ALAN BRUNS . . . California State Polytechnic College . . . mechanical engineer, Mare Island Naval Shipyard.

HERBERT S. BURDEN, JR. . . . California State Polytechnic College . . . design engineer, liquid rocket plant, Aerojet-General Corp.

WILLIAM G. BURGER . . . Manhattan College . . . Sikorsky Aircraft Co.

LOUIS P. CAIRA . . . Drexel Institute of Technology . . . Ford Motor Co.

JOHN N. CALANDRO . . . University of Detroit . . . Defense Systems Division, GMC.

DAVID W. CAMP . . . Oklahoma State University . . . Material Transportation Command, Civil Service.

RONALD A. CAMPBELL . . . University of Oklahoma . . . Ingersall-Rand Co.

JAMES S. CARLYLE . . . San Diego State College . . . General Electric Co.

JAMES H. CARR . . . Tri-State College . . . Barber-Greene Co.

GEORGE W. CARRIE . . . Indiana Technical College . . . design engineer, Surface Combustion Corp.

JERRY F. CHASE . . . General Motors Institute . . . analyst, Fisher Body Division, GMC.

JEROME T. CIPKOWSKI . . . University of Detroit . . . general engineer, Ordnance Tank Automotive Command.

PHILLIP G. CLARK . . . University of Washington . . . associate engineer, Missiles and Space Division, Lockheed Aircraft Corp.

THOMAS J. CLECKNER . . . University of Illinois . . . Link Belt Co.

MARTIN COHEN . . . The City College . . . Eclipse Pioneer Division, Bendix Corp.

WILLIAM A. COLE . . . General Motors Institute . . . process engineer, Delco Moraine Division, GMC.

TRACY K. COLEMAN . . . Northrop Aeronautical Institute . . . engineering draftsman, Douglas Aircraft Co.

NELSON M. COOK, JR. . . . Tri-State College . . . Newport News Shipbuilding and Dry Dock Co.

JAMES A. COWEN, JR. . . . Chrysler Institute of Engineering . . . development engineer, Schlumberger Well Surveying Corp.

HOWARD J. CRAWFORD, JR. . . . Lawrence Institute of Technology . . . Maxitral Co.

KENDALL C. CRAWFORD . . . Purdue University . . . research engineer, Wood River Research Laboratory, Shell Oil Co.

WILLIAM N. CURSON . . . Missouri School of Mines and Metallurgy . . . industrial engineer, Aluminium Co. of America.

ROBERT L. CURTIS . . . University of Manitoba . . . design engineer, Dryden Paper Co. Ltd.

LEONARD CYR, JR. . . . University of Michigan . . . Pontiac Motor Division, GMC.

FREDERIC C. DAHMS . . . San Diego State College . . . assistant engineer, General Atomic Division, General Dynamics Corp.

MICHAEL D'AMBROSIO . . . The City College . . . mechanical engineer, Norden Division, United Aircraft Corp.

JOHN F. DAMKE . . . Missouri School of Mines and Metallurgy . . . staff member, Sandia Corp.

DAN C. DANES . . . Milwaukee School of Engineering . . . Quaker Oats Co.

F. KENNETH DANIEL . . . University of Southwestern Louisiana . . . Schlumberger Well Surveying Corp.

PETER A. DANIELSON . . . Milwaukee School of Engineering . . . research and development engineer, Surface Combustion Division, Midland Ross Corp.

MICHAEL J. DEMPSEY . . . Michigan College of Mining and Technology . . . associate tool engineer, Boeing Airplane Co.

DARRELL H. DENGLER . . . General Motors Institute . . . product engineer, Saginaw Steering Gear Division, GMC.

JOSEPH DENNEEN . . . Manhattan College . . . installation engineer, Western Electric Co.

FRANK W. DENZEL, JR. . . . General Motors Institute . . . Ternstedt Division, GMC.

GLEN A. DE VORE . . . University of Washington . . . Boeing Airplane Co.

JOHN E. DICK . . . General Motors Institute . . . General Motors Corp.

THOMAS S. DIERDA . . . General Motors Institute . . . laboratory tester, Diesel Equipment Division, GMC.

JOHN R. DOUGHERTY . . . University of Pittsburgh . . . Bell Telephone Co. of Pa.

RICHARD L. DRANE . . . University of Illinois . . . field service trainee, RCA Whirlpool Corp.

WILLIAM D. M. DROWNE . . . California State Polytechnic College . . . nuclear engineer, Mare Island Naval Shipyard.

DONALD F. DUNCAN . . . Oklahoma State University . . . petroleum engineer, Kerr McGee Oil Inc.

JOHN D. ELAM . . . Parks College of Aeronautical Technology . . . aeronautical engineer, Aeronautical Systems Division, Wright Field, Dayton, Ohio.

JAMES N. ELLIS . . . Michigan State University . . . Chevrolet Motor Division, GMC.

KENTON C. ENSOR . . . University of Michigan . . . installation point supervisor, American Coleman Co.

JACK EUNSON . . . Purdue University . . . Cummins Engine Co.

LEONARD FARANO . . . The City College . . . systems engineer, International Business Machines Corp.

ROBERT N. FARKAS . . . New York University . . . project engineer, Vibration Mountings and Controls, Inc.

C. ROBERT FEDAK . . . General Motors Institute . . . production tooling engineer, Buick-Oldsmobile-Pontiac Assembly Division, GMC.

FRED G. FISCHER . . . Washington

State University . . . Pratt and Whitney Aircraft, Division, United Aircraft Corp.

CHARLES P. FISHER . . . Milwaukee School of Engineering . . . industrial engineer, Motorola, Inc.

JAMES N. FLECK . . . The Pennsylvania State University . . . research and development metallurgist, Meehanite Metal Corp.

HENRY H. FORRESTER, JR. . . . University of Southwestern Louisiana . . . Shell Chemical Co.

MEL FRIEDMAN . . . The City College . . . mechanical engineer, Polaroid Corp.; part time graduate studies, Massachusetts Institute of Technology.

ROBERT A. FULLER . . . Queen's University . . . technical assistant, Atlas Steels, Ltd.

PIERRE GADBOIS . . . Ecole Polytechnique . . . Shell Oil Co. of Canada, Ltd.

CHARLES E. GAGE . . . Oklahoma State University . . . mechanical engineer, Federal Aviation Administration.

JON R. GARCIA . . . California State Polytechnic College . . . Hanford Atomic Products Operation, General Electric Co.

CHARLES J. GAUTIER . . . University of Southwestern Louisiana . . . mechanical engineer, U. S. Naval Propellant Plant, Indian Head, Md.

GERALD E. GAYLORD . . . Missouri School of Mines and Metallurgy . . . design engineer, Newport News Shipbuilding and Dry Dock Co.

JOHN E. GETZ . . . University of Detroit . . . Mishawaka Division, Bendix Corp.

CARLTON S. GIBSON . . . Clemson College . . . Ecusta Division, Olin Mathieson Chemical Corp.

CURTIS A. GILMORE . . . Purdue University . . . project engineer, Wayne Works Division, Divco-Wayne Corp.

DALE E. GOOD . . . Tri-State College . . . Crystal Dairy, Rochester, Ind.

JOHN H. GRAY, JR. . . . University of Washington . . . associate engineer, Boeing Airplane Co; part time graduate studies.

ROBERT W. GRAY . . . General Motors Institute . . . designer, Chevrolet Engineering Center, Chevrolet Division, GMC.

RICHARD E. GREGG . . . San Jose State College . . . design progress estimater, Boeing Airplane Co.

CARROLL A. GRIGSBY . . . Wayne State University . . . technical staff member; out side plant development, Bell Telephone Laboratories, Inc.

ROBERT B. GRIGSBY . . . Chrysler Institute of Engineering . . . field service engineer, Convair Astronautics Division, General Dynamics Corp.

ROBERT E. HAACK . . . Tri-State College . . . Cincinnati Milling Machine Co.

EDWARD C. HAGEMANN . . . University of Washington . . . Standard Oil Co. of Calif.

HARRY A. HALLEWELL . . . University of Manitoba . . . Consolidated Paper Corp., Ltd.

JOHN T. HALL . . . Tri-State College . . . maintenance equipment developer, U. S. Steel Co.

DONALD L. HAMRE . . . University of Illinois . . . environmental test engineer, Flexonics Research Laboratories.

KEITH M. HANEY . . . General Motors Institute . . . cooperative engineer, fifth year thesis program, AC Spark Plug Division, GMC.

ROBERT H. HAYES . . . Missouri School of Mines and Metallurgy . . . power plant engineer, Illinois Power Co.

PHILLIP K. HEACOCK . . . University of Illinois . . . junior mechanical engineer, Pontiac Motor Division, GMC.

PAUL A. HEADY, JR. . . . California State Polytechnic College . . . Missiles and Space Division, Lockheed Aircraft Corp.

FREDERICK J. HEATLEY . . . University of Toronto . . . W. J. Gage Co., Ltd.

RODNEY W. HEBERT . . . Agricultural and Mechanical College of Texas . . . Westinghouse Electric Co.

ROBERT E. HENDERSON . . . Missouri School of Mines and Metallurgy . . . mechanical engineer, GS-7, Aeronautical Systems Division, Air Force Systems Command, Wright Patterson Air Force Base.

ROBERT M. HEPWORTH . . . Fenn College . . . mechanical engineer, Lubrizol Corp.

NORMAN K. HILD . . . Bradley University . . . design engineer, North American Aviation, Inc.

HARRY HILL . . . University of Manitoba . . . sales engineer, Canadian Pratt & Whitney Aircraft, Ltd.

J. FREDRICK HILL . . . Wayne State University . . . management trainee, Ex-Cell-O Corp.

ROBERT K. HILLQUIST . . . Case Institute of Technology, Proving Ground Section, GMC.

JAMES W. HINES . . . Missouri School of Mines and Metallurgy . . . associate tool engineer, Boeing Airplane Co.

DAVID HIRSCHFELD . . . The City College . . . experimental engineer, Pratt & Whitney Aircraft, Division of United Aircraft Corp.

RON HOUSEHOLDER . . . Oregon State College . . . Hyster Co.

JAMES L. HODGES . . . Stevens Institute of Technology . . . mechanical engineer, Boeing Airplane Co.

CLARENCE H. N. HODGSON . . . University of Saskatchewan . . . industrial engineer, Martin Paper Products.

RICHARD L. HOLLAR . . . Purdue University . . . design engineer, Motor Truck Division, International Harvester Co.

RUSSELL C. HOLMES . . . Wayne State University . . . project engineer, Ternstedt Division, GMC.

continued

. . . who are doing graduate work

R. C. BIGGS . . . Queen's University . . . graduate work on M.S. in Mechanical Engineering at Stanford University.

GENE K. BAXTER . . . University of Idaho . . . graduate study at Syracuse University.

HOWELL K. BREWER . . . Fenn College . . . graduate study, Polytechnic School of Turin, Italy.

T. MICHAEL BROGAN . . . General Motors Institute . . . fifth year student, Detroit Diesel Engine Division, GMC.

JOHN M. CARNEY . . . University of Oklahoma . . . graduate study, Purdue University.

DAVID E. COLE . . . University of Michigan . . . graduate work on Ph.D. at University of Michigan.

ROBERT W. DEUEL . . . General Motors Institute . . . graduate work on M.S. at the University of Chicago.

DOMINIO A. DiCICCO . . . University of Detroit . . . graduate work on M.S. at Purdue University.

WALTER FROST . . . University of Washington . . . graduate study, University of Washington.

JAMES D. GREEN . . . General Motors Institute . . . fifth year student, Delco Radio Division, GMC.

WILLIAM P. GRUBER . . . University of Washington . . . graduate study, University of Washington.

MAX E. HINE . . . Purdue University . . . graduate study, Purdue University.

GEORGE W. KELSH . . . University of Florida . . . graduate study, University of Florida.

JOE L. KING . . . San Diego State College . . . graduate work on M.S. in Mechanical Engineering at San Diego State College.

PETER MORELEY . . . Stanford University . . . graduate work.

HENRY K. NEWHALL . . . University of California (Berkeley) . . . graduate study at University of California.

THOMAS A. PHILLIPS . . . University of Detroit . . . graduate work as research assistant at Northwestern University.

NICHOLAS F. PIER . . . Marquette University . . . graduate study at Massachusetts Institute of Technology.

KENNETH A. RATHJEN . . . The City College . . . graduate study at Massachusetts Institute of Technology.

JOHN SRNECZ . . . Stevens Institute of Technology . . . graduate assistant at Stevens Institute of Technology.

Among SAE Enrolled Students

. . . who have entered industry (continued)

HAROLD M. HOLROYDE . . . University of Manitoba . . . staff engineer, extrusion department, Kingston Works, Aluminum Co. of Canada.

BILLY H. HOWELL . . . University of Wyoming . . . Chevrolet Motor Division, GMC.

THOMAS HRYNIK . . . University of Michigan . . . Fisher Body Division, GMC.

CHARLES HSU . . . University of Wisconsin . . . research scientist, American Radiator & Standard Sanitary Engineering Corp.

FRED B. HUDSPETH . . . Agricultural and Mechanical College of Texas . . . design engineer, Monsanto Chemical Co.

JAMES T. HULBERT . . . University of Washington . . . development engineer, Aeronutronic Division, Ford Motor Co.

VICTOR HUMANIVK . . . University of Alberta . . . Western Chemicals, Ltd.

CLAUDE W. HUNTER . . . University of Texas . . . Cameron Iron Works.

WENDELL G. HUOTARI . . . Michigan College of Mining & Technology . . . base installation, Boeing Airplane Co.

LYLE L. ILLS . . . University of Idaho . . . manufacturing trainee, General Electric Co.

CARLO A. IORIO . . . Lawrence Institute of Technology . . . junior civil engineer, The City of Detroit.

KENNETH H. IZUMIKAWA . . . Oregon State College . . . associate engineer, Boeing Airplane Co.

ROBERT T. JACKAL . . . Indiana Technical College . . . experimental test engineer, Research and Development Center, Pratt & Whitney Aircraft, Division of United Aircraft Corp.

NAROTTAM L. JAIN . . . Michigan State University . . . reader in mechanical engineering, Government Engineering College, Jabalpur, M. P., India.

WILLIAM S. JAKUBCAK . . . University of Saskatchewan . . . Construction Department, Dominion Bridge Co., Ltd.

DALE T. JARMUSH . . . Case Institute of Technology . . . mechanical engineer, Keithley Instruments.

WAYNE JARVI . . . Michigan College of Mining and Technology . . . works engineer, Union Carbide Consumer Products, Union Carbide Corp.

DON L. JENSEN . . . Utah State University . . . management trainee, Utah Division, Kennecott Copper Corp.

FREDERICK D. JOHNSON . . . Wayne State University . . . test engineer, Ford Motor Co.; part time student.

TERENCE A. JOHNSON . . . University of Toronto . . . mechanical engineer, Underwood Typewriters Ltd., Canada.

NEIL JOHNSTON . . . General Motors Institute . . . detail engineer, Buick Motor Division, GMC.

JOHN E. JOINER . . . Queen's University . . . development engineer, Polymer Corp., Ltd.

RICHARD A. JONES . . . Bradley University . . . research engineer, Research Laboratory, Shell Oil Co.

JOEL MACK JORDAN . . . Clemson College . . . Newport News Shipbuilding and Dry Dock Co.

JOHN P. KAMMAN . . . Purdue University . . . production method and layout engineer, Eli Lilly & Co.

WILLIAM F. KANE . . . Pennsylvania Military College . . . mechanical engineer, Allis-Chalmers Mfg. Co.

ROGER KANNADY . . . Arlington State College . . . advertising assistant, Texas Jaycees.

SEKKAPPAN KANNAPPAN . . . Michigan State University . . . reader in mechanical engineering, Annamalai University, India.

BRUCE D. KELLNER . . . Chrysler Institute of Engineering . . . cryogenic products sales development department, Linde Co., Union Carbide Corp.

CHARLES E. KELLNER . . . University of Manitoba . . . project engineer, Procter & Gamble Co. of Canada Ltd.

JAMES B. KELLY . . . General Motors Institute . . . junior process engineer, plastics development section Allison Division, GMC.

JAN KERREBYN, JR. . . . Massachusetts Institute of Technology . . . Deering Milliken Service Corp.

MICHAEL KESTENBAUM . . . The City College . . . mechanical engineer, Convair Astronautics Division, General Dynamics Corp.

CHARLES B. KIMBALL . . . San Diego State College . . . management trainee, Pacific Telephone and Telegraph Co.

KENNETH KINAS . . . University of Wisconsin . . . General Tire and Rubber Co.

PATRICK G. KINDRED . . . California State Polytechnic College . . . management trainee, Equipment Division, Guy F. Atkinson Co.

JERRY M. KLIEWER . . . Oklahoma State University . . . Oklahoma Gas and Electric Co.

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JAMES P. KUHN . . . Marquette University . . . manufacturing trainee, General Electric Co.

SIEGFRIED E. KUHN . . . St. Louis University, Parks Air College . . . airframe and powerplant mechanic, Mohawk Airlines, Inc.

FRANK J. KEYJAN . . . The City College . . . engineering science trainee, General Electric Co.

RICHARD E. KUSTER . . . University of Illinois . . . management trainee, Ex-Cell-O Corp.

ROBERT M. LAIRD . . . California State Polytechnic College . . . Aerojet General Corp.

LAWRENCE W. LANG . . . University of Detroit . . . Chevrolet Motor Division, GMC.

JOSEPH G. LANGENSTEIN . . . Indiana Technical College . . . Conax Corp.

GEORGE W. LECK III . . . Missouri School of Mines and Metallurgy . . . research engineer, Cities Service Research and Development Co.

WILLIAM R. LEE . . . General Motors Institute . . . Ternstedt Division, GMC.

NOEL LEIFER . . . The City College . . . mechanical engineer, Bell Telephone Laboratories.

RODNEY A. LE MENSE . . . Marquette University . . . experimental engineer, A. O. Smith Corp.

THOMAS G. LENOX . . . Drexel Institute of Technology . . . experimental engineering department, Pratt and Whitney Aircraft, Division of United Aircraft Corp.

RONALD A. LICHALK . . . University of Pittsburgh . . . Radio Corp. of America.

DONALD A. LINDVAL . . . Chrysler Institute of Engineering . . . resident engineer, Chrysler Corp.

RICHARD H. LINE . . . Carnegie Institute of Technology . . . Goodyear Tire and Rubber Co.

LUTHER T. LOPER II . . . San Jose State College . . . design engineer, liquid rocket plant, Aerojet General Corp.

KENNETH P. LUBER . . . Parks College . . . aeronautical engineer, U. S. Army Transportation Material Command, St. Louis, Mo.

GLEN S. LYALL . . . General Motors Institute . . . Cadillac Motor Car Division, GMC.

JAMES V. LYONS . . . University of Detroit . . . Boeing Airplane Co.

RODERICK D. MacLEOD . . . General Motors Institute . . . Buick Motor Division, GMC.

DONALD B. MAKELIN . . . General Motors Institute . . . draftsman, Fisher Body Division, GMC.

WILLIAM L. MALLORY . . . Michigan College of Mining and Technology . . . sales engineer, Ingersoll-Rand Co.

ALEXANDER S. MARCH . . . Milwaukee School of Engineering . . . associate tool engineer, Boeing Airplane Co.

FRANKLIN L. MARSH, JR. . . . San Diego State College . . . teacher, Department of Public Instruction, State of Hawaii.

TED P. MARTENS . . . University of Pittsburgh . . . technical representative, Plastics Division, Koppers Co., Inc.

OLEH MASLUK . . . Aero-Space Institute . . . draftsman, Leonard Peterson & Co.

RICHARD E. MAXWELL . . . Chrysler Institute of Engineering . . . research engineer, Research Department, Caterpillar Tractor Co.

PETER G. MAYOR . . . Queen's University . . . Inspection Services, Department of National Defense.

DAVID E. McCAHILL . . . Carnegie Institute of Technology . . . design engineer, Mesta Machine Co.

HAROLD S. McCLAIN . . . University of Detroit . . . field engineer, Western Union Telegraph Co.

WILLIAM J. McKEARNEY . . . University of Miami . . . research engineer, Rocketdyne Division, North American Aviation Co.

WILLIAM H. McQUEEN . . . University of British Columbia . . . Consolidated Mining and Smelting Co.

DAVID L. MEHALL . . . General Motors Institute . . . Inland Mfg. Division, GMC.

RICHARD F. MELSHEIMER . . . California State Polytechnic College . . . Melfred Welding Mfg. Co.

JOHN R. MELTON . . . University of Washington . . . Engineering Development Laboratory, Procter & Gamble Co.

STERRET METHENY . . . University of Washington . . . associate engineer, Aeronutronic Division, Ford Motor Co.

WILLIAM A. MILLER . . . University of New Mexico . . . service engineer, Ingersoll-Rand Co.

JOHN F. MILTON . . . University of Miami . . . mechanical engineer GS 7, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring Md.

H. W. MITCHELL . . . University of Arizona . . . mechanical engineer, General Electric Co.

JAMES N. MITCHELL . . . California State Polytechnic College . . . research engineer Rocketdyne Division North American Aviation Co.

WILLIAM H. MOORE . . . Drexel Institute of Technology . . . mechanical engineer, Department of Agriculture, U. S. Forest Service.

GERALD N. MORRISON . . . General Motors Institute . . . junior project engineer, Oldsmobile Division, GMC.

WILLIAM A. MUELLER . . . Michigan College of Mining and Technology . . . Technical Center, GMC.

RICHARD G. MUMPER . . . Milwaukee School of Engineering . . . Tool and Die Design Division, Boeing Airplane Co.

ELON C. MUNGER . . . University of Illinois . . . assistant engineer, Underwriters' Laboratories, Inc.

LEE R. MUSSON . . . General Motors Institute . . . Pontiac Motor Division, GMC.

HAROLD R. MYERS . . . University of Oklahoma . . . research, Ecusta Paper Division, Olin Mathieson Chemical Corp.

HUGH I. MYERS . . . Michigan State University . . . design, K. W. Dart Co.

JOSEPH M. NEUBAUER . . . Milwaukee School of Engineering . . . Western Electric Corp.

JAMES P. OAKES . . . Los Angeles State College . . . sales engineer, Shell Oil Co.

NORITADO OISHI . . . University of Michigan . . . research engineer, Yanmer Diesel Engineering Co., Ltd. Tokyo, Japan.

DONALD E. OREM . . . Purdue University . . . project engineer, Marmon-Herrington Co., Inc.

MICHAEL J. OSTRELICH . . . New York University . . . Western Union Telegraph Co.

GERALD N. OSTROM . . . Northrop Aeronautical Institute . . . design engineer, North American Aviation Co.

JAMES A. OTT . . . University of Pittsburgh . . . production control, Missile and Space Vehicle Department, General Electric Co.

BUD A. PAINE . . . California State Polytechnic College . . . Spectrol Electronics Co.

JAMES S. PARKINSON . . . Utah State University . . . inspector, Thiokol Chemical Corp.

DONALD C. PATSTON . . . California State Polytechnic College . . . design engineer, Hiller Aircraft Co.

DAVID J. PAYNE . . . North Carolina State College . . . engineering trainee, Chevrolet Motor Division, GMC.

WILLIAM W. PEEL . . . University of Toronto . . . General Motors of Canada Ltd.

ROY G. PEARSON . . . Lawrence Institute of Technology . . . sales engineer, American Standard Products, Ltd.

GARY D. PENNYBAKER . . . Tri State College . . . Dana Corp.

DEAN T. PETERS . . . University of Saskatchewan . . . industrial representative, Texaco Canada, Ltd.

ROBERT A. PETERSON . . . Manhattan College . . . junior mechanical

continued

. . . who have entered military service

JACK F. ADAMS . . . Queen's University . . . Royal Canadian Air Force.

E. N. BRYGA . . . Queen's University . . . flying officer, Royal Canadian Air Force.

JON R. CHURGAY . . . University of Detroit.

REX C. EASLEY . . . Agricultural and Mechanical College of Texas.

SIGURD FOLSTAD . . . University of Massachusetts.

HARVEY L. GORDON . . . New York University.

DONALD C. GRAESSER . . . University of Illinois . . . Army.

A. ANDREW GRAY . . . George Washington University.

CARL V. HAJEK . . . Michigan College of Mining and Technology.

LARRY K. JONES . . . Purdue University.

WINSLOW MOORE . . . California State Polytechnic College . . . Naval Air O.C.S., Rhode Island.

LAWRENCE MUSINSKI . . . University of Detroit.

L. ROBERT MYERS . . . Purdue University.

RICHARD F. OLSON . . . University of Illinois . . . the Marines.

CHARLES N. ROLLINGER . . . Northwestern University . . . USAF Academy.

1/Lt. WARD C. ROMAN . . . mechanical engineer, Dyna-Soar Project-Propulsion and Booster Section, Wright Patterson AFB while completing graduate work at Ohio State University.

JAMES C. RUDEEN . . . San Diego State College . . . U. S. Navy O.C.S.

MICHAEL D. RYAN . . . Parks College . . . Missouri Air National Guard.

RAY C. SHUBERT . . . University of Idaho . . . Ensign USNR, Flight Training School, Pensacola, Fla.

STANLEY S. SWIEKAR, JR. . . . Parks College . . . Naval Aviation.

ED SYMONS . . . Queen's University . . . flying officer, Royal Canadian Air Force.

ROGER TALBERT . . . Missouri School of Mines and Metallurgy.

JOHN A. WIDGER . . . University of Saskatchewan . . . aircraft engineering officer, Royal Canadian Air Force.

HOWARD WOODARD . . . University of Oklahoma.

Among SAE Enrolled Students

. . . who have entered industry (continued)

engineer, Electronics Systems Division, Fairchild Stratos Corp.

RONALD G. PETERSON . . . Chrysler Institute of Engineering . . . associate engineer, Boeing Airplane Co.

DAVID M. PETTIT . . . Washington State University . . . associate engineer, Astronautics Division, General Dynamics Corp.

VERNON J. PHELPS . . . University of Washington . . . associate engineer, Boeing Airplane Co.

JOHN PIERCE . . . General Motors Institute . . . test engineer, Chevrolet Engineering Center, GMC.

ARTHUR L. PLINSKI . . . Lawrence Institute of Technology . . . design checker, Engineering Division, Chrysler Corp.

THOMAS A. POTENZA . . . The City College . . . mechanical engineer, Sperry Gyroscope Co.

GORDON F. QUINN . . . Parks College . . . aeronautical engineer, Aeronautical Systems Division, Wright-Patterson Air Force Base, USAF.

EDWARD A. RADWANSKI . . . University of Saskatchewan . . . project engineer, Canada Packers, Ltd.

JERRY G. RANDOLPH . . . Arlington State College . . . test conductor, Bacchus Plant, Hercules Powder Co.

CHARLES D. REESE . . . University of Oklahoma . . . Allis-Chalmers Mfg. Co.

E. JACK RENDELL . . . California State Polytechnic College . . . design engineer, Aerojet-General Corp.

BURTON M. ROBERTS . . . Academy of Aeronautics . . . bench mechanic, Republic Aviation Corp.

LARRY A. ROBERTS . . . Missouri School of Mines and Metallurgy . . . test engineer, Aeronautical Systems Division, Wright-Patterson Air Force Base, USAF.

W. STEWART ROBERTS, JR. . . . Syracuse University . . . Caterpillar Tractor Co.

DONALD C. ROOT . . . Worcester Polytechnic Institute . . . Farrel Birmingham Co.

DAVID ROSS . . . University of Idaho . . . Hercules Powder Co.

JAMES L. ROSS . . . Purdue University . . . plant layout and construction engineer, Radio Corp. of America.

GUY ROY . . . Ecole Polytechnique . . . Consolidated Paper Corp., Ltd.

ROWAN J. RUDNITSKY . . . Wayne State University . . . junior engineer, test and development group, Cadillac Motor Car Division, GMC.

DONALD E. RUFF . . . California State Polytechnic College . . . Department of the Navy, Naval Ordnance Test Station, China Lake Calif.

JOHN E. RUPPENTHAL . . . University of Wisconsin . . . test engineer, Truck Division, International Harvester Co.

TERRY A. RUTLIN . . . California State Polytechnic College . . . Litton Systems Inc.

GERALD D. SAHLEEN . . . Washington State University . . . mechanical engineer, Puget Sound Naval Shipyard.

CALEN J. SANDWITH . . . University of Washington . . . General Electric Co.

RICHARD P. SAVIO . . . Marquette University . . . graduate trainee, Allis-Chalmers Mfg. Co.

STAN SAWABINI . . . Oklahoma State University . . . Signal Drilling and Exploration, Inc.

ALBERT E. SICKINGER . . . Chrysler Institute of Engineering . . . test and development engineer, Defence Division, Chrysler Corp.

J. LEONARD SCHALLER, JR. . . . Chrysler Institute of Engineering . . . project engineer, Conco Engineering Works, Inc.

WAYNE R. SCHERER . . . California State Polytechnic College . . . production assistant, Kaiser Steel Corp.

ARTHUR J. SCHMIDT . . . University of British Colombia . . . Atomic Energy of Canada, Ltd.

ROBERT E. SCHURR . . . Indiana Technical College . . . mechanical engineer, Electric Motors and Spec.

JOHN SHANKS, JR. . . . California State Polytechnic College . . . production engineer, Aerojet-General Corp.

NORMAN SHELTON . . . University of Wisconsin . . . test engineer, American Motors Corp.

FREDERICK J. SHORE . . . The City College . . . test engineer, B. G. Corp.

PAUL M. SINCLAIR . . . California State Polytechnic Institute . . . associate engineer, Norair Division, Northrup Aircraft Co.

DONALD G. SLANE . . . University of Illinois . . . mechanical engineer, Cummins Diesel Engine Co.

RAY SOETERS . . . Wayne State University . . . Holley Carburetor Co.

GERALD I. SOLSRUD . . . University of Wisconsin . . . design engineer, Motor Truck Division, International Harvester Co.

JOHN F. SOVIS . . . Chrysler Institute of Engineering . . . Whirlpool Corp.

GARY D. SPABERG . . . University of Idaho . . . Missile Division, Douglas Aircraft Co.

PAUL SPANIER . . . Marquette University . . . quality control engineer, Kearney and Trecker Corp.

ERWIN T. SPENCER . . . California State Polytechnic College . . . associate engineer, Douglas Aircraft Co.

LEONARD SPERBER . . . The City College . . . design engineer, Hamilton Standard Division, United Aircraft Corp.

BRIAN SPILLANE . . . University of Detroit . . . associate engineer, Astronautics Division, General Dynamics Corp.

JACK L. STARK . . . Purdue University . . . test engineer, International Harvester Co.

ROBERT STOBB . . . Detroit Institute of Technology . . . test engineer, Rockwell Standard Corp.

DAVID E. STOCK . . . Pennsylvania State University . . . Pratt and Whitney Aircraft, Division of United Aircraft Corp.

KENNETH L. STOUFFER . . . Carnegie Institute of Technology . . . junior design engineer, Material Handling Division, Rust Engineering Co.

HARRISON STREETER . . . University of Illinois . . . instructor, University of Illinois.

ED J. SZYMCZAK . . . Agricultural and Mechanical College of Texas . . . design engineer, Cameron Iron Works, Inc.

DAVID M. TENNISWOOD . . . Michigan State University . . . engineering staff member, Ford Motor Co.

FERNAND TETREAULT . . . Ecole Polytechnique . . . project engineer, 'Commission des Services Electriques' of the city of Montreal.

DARRYL W. THOMPSON . . . California State Polytechnic College . . . production engineer, Lebrascope Division, General Precision Co.

HAROLD R. THOMPSON . . . California State Polytechnic College . . . associate engineer, Missiles and Space Division, Lockheed Aircraft Corp.

HUBERT G. TOLL . . . California State Polytechnic College . . . sales engineer, Commercial Division, Los Angeles Branch, Minneopolis-Honeywell Regulator Co.

THOMAS V. TRAVAGLINI . . . Pennsylvania Military College . . . mechanical engineer, Sun Shipbuilding and Dry Dock Co.

ABRAHAM UNDERWOOD . . . Michigan College of Mining and Technology . . . company representative, Boeing Airplane Co.

G. A. VAN DER WAERDEN . . . University of Detroit . . . design engineer, Missile Division, Chrysler Corp.

PAUL VERMAELEN . . . Yale University . . . design engineer, M. W. Kellogg Co.

CHARLES E. VAUGHN, JR. . . . Oklahoma State University . . . engineer, General Electric Co.

ROBERT J. VILLEMARETTE . . . University of Southwestern Louisiana . . . mechanical engineer, U. S. Naval Weapons Laboratory, Dalgren, Va.

DAVID VIOLETTA . . . Chrysler Institute of Engineering . . . junior project engineer, Oldsmobile Division, GMC.

MARTIN C. VISCO . . . Manhattan College . . . simulator and Data Proc-

essing Department, Fairchild Astrionics Division.

OLIVER H. VOGT . . . Queen's University . . . junior analyst, Algoma Steel Co.

JOHN C. VON SEGGERN . . . California State Polytechnic College . . . Westinghouse Electric Corp.

JEFFERY WALDMANN . . . The City College . . . New York Naval Shipyard.

GEORGE E. WALKER, JR. . . . University of Washington . . . mechanical engineer, structural test, Transport Division, Boeing Airplane Co.

JAMES W. WALKER . . . Missouri School of Mines and Metallurgy . . . graduate student trainee . . . Westinghouse Electric Co.

PAUL J. WALKER . . . University of Wisconsin . . . research engineer, Allen-Bradley Co.

W. TED WALRICH . . . University of Illinois . . . development engineer, Outboard Marine Corp.

MILTON J. WEBB . . . California State Polytechnic College . . . production assistant, Metallurgy Division, Kaiser Steel Corp.

ROGER J. WEDDLE . . . Bradley University . . . Le Tourneau-Westinghouse Co.

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BOBBY R. WHISENANT . . . Arlington State College . . . associate engineer, product design, Chance Vought Aircraft Inc.

JAMES E. WHITE . . . University of Miami . . . experimental engineer, Research and Development Center, Pratt and Whitney Aircraft, Division of United Aircraft Corp.

RICHARD J. WHOULEY . . . Milwaukee School of Engineering . . . mechanical engineer, Shipbuilding Division, Bethlehem Steel Co.

WARREN A. WICKLAND . . . University of Michigan . . . Chevrolet Motor Division, GMC.

W. DANA WILCOCK . . . Worcester Polytechnic Institute . . . Rochester Products Division, GMC.

ROBERT A. WISE . . . Indiana Technical College . . . Surface Combustion Corp.

ROBERT L. WOLFBERG . . . University of Illinois . . . mechanical engineer, Hallicrafters Co.

EARL S. WOODS, JR. . . . General Motors Institute . . . graduate engineer, Chevrolet Motor Division, GMC.

ROBERT L. WOODS . . . California State Polytechnic College . . . Air Reduction Pacific Co.

ROBERT S. ZIELES . . . University of Pittsburgh . . . Bell Telephone Laboratories, Inc.

BURT ZIMMERMAN . . . The City College . . . mechanical engineer, New York Naval Shipyard.

FREDERICK A. ZWEMER . . . General Motors Institute . . . foreman, plating department, Chevrolet Motors Division, GMC.

SAE National Meetings

1961

September 11–14
"Heavy Duty" Vehicle
(combined Farm, Construction and Industrial Machinery; Powerplant; and Transportation Meeting, including production forum and engineering display)
Milwaukee Auditorium, Milwaukee, Wis.

October 9–13
Aeronautic and Space Engineering and Manufacturing
(including engineering display)
The Ambassador, Los Angeles, Calif.

November 8–10
Fuels and Lubricants
Shamrock Hotel, Houston, Texas

1962

January 8–12
Automotive Engineering Congress and Exposition
Cobo Hall, Detroit, Mich.

March 12–16
Automobile Week
(combined National Automobile and Production Meetings)
Sheraton-Cadillac, Detroit, Mich.

April 3–6
Aeronautic
(including production forum)
Hotel Commodore, New York, N. Y.

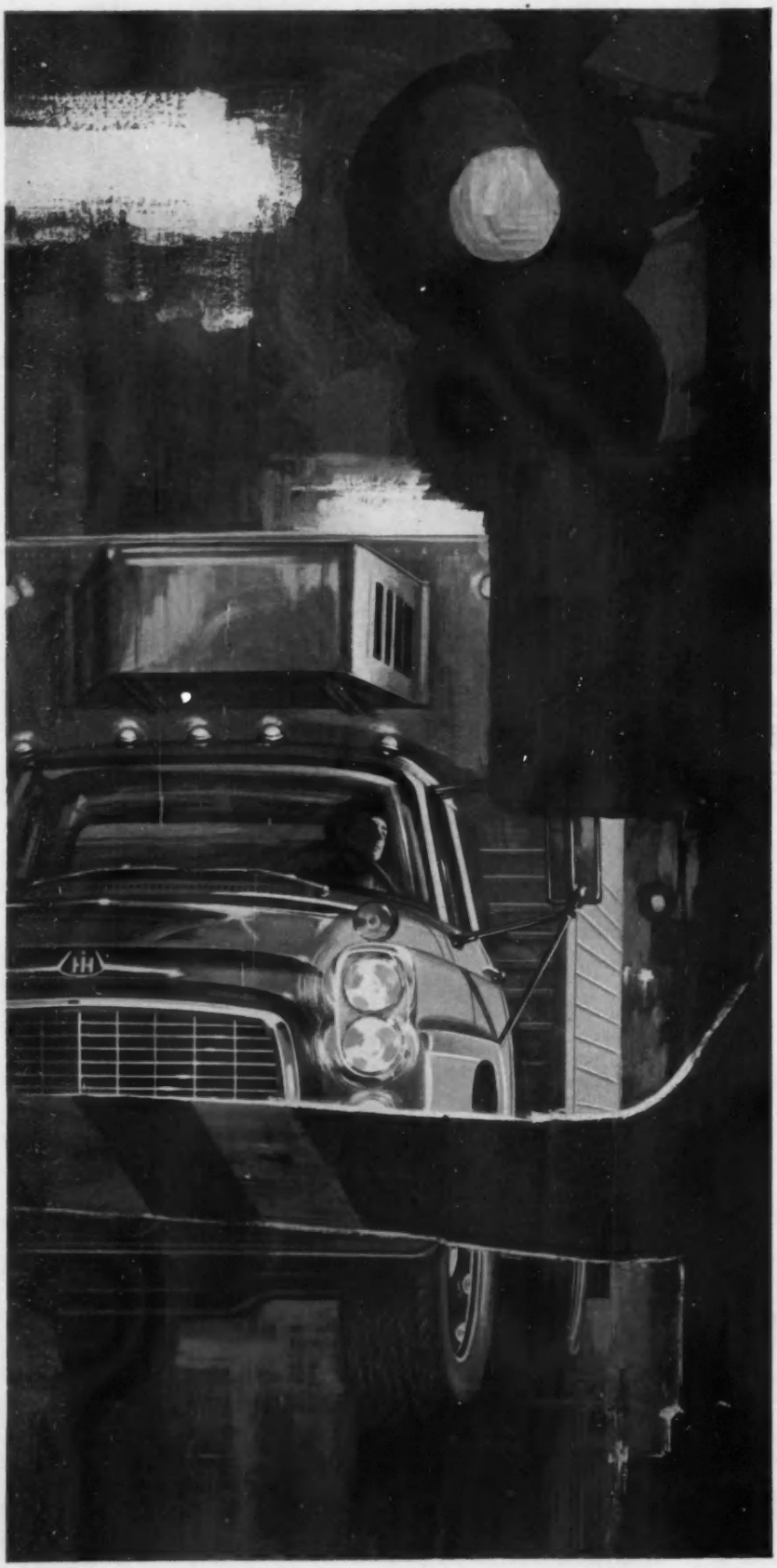
June 11–15
Summer
Chalfonte-Haddon Hall, Atlantic City, N. J.

August 13–16
National West Coast
Biltmore Hotel, Los Angeles, Calif.

September 10–13
Farm, Construction, and Industrial Machinery
(including production forum and engineering display)
Milwaukee Auditorium, Milwaukee, Wis.

October 8–12
Aeronautic and Space Engineering and Manufacturing
(including manufacturing forum and engineering display)
The Ambassador, Los Angeles, Calif.

October 29–November 2
Combined National Fuels and Lubricants; Powerplant; and Transportation Meetings
Bellevue Stratford, Philadelphia, Pa.



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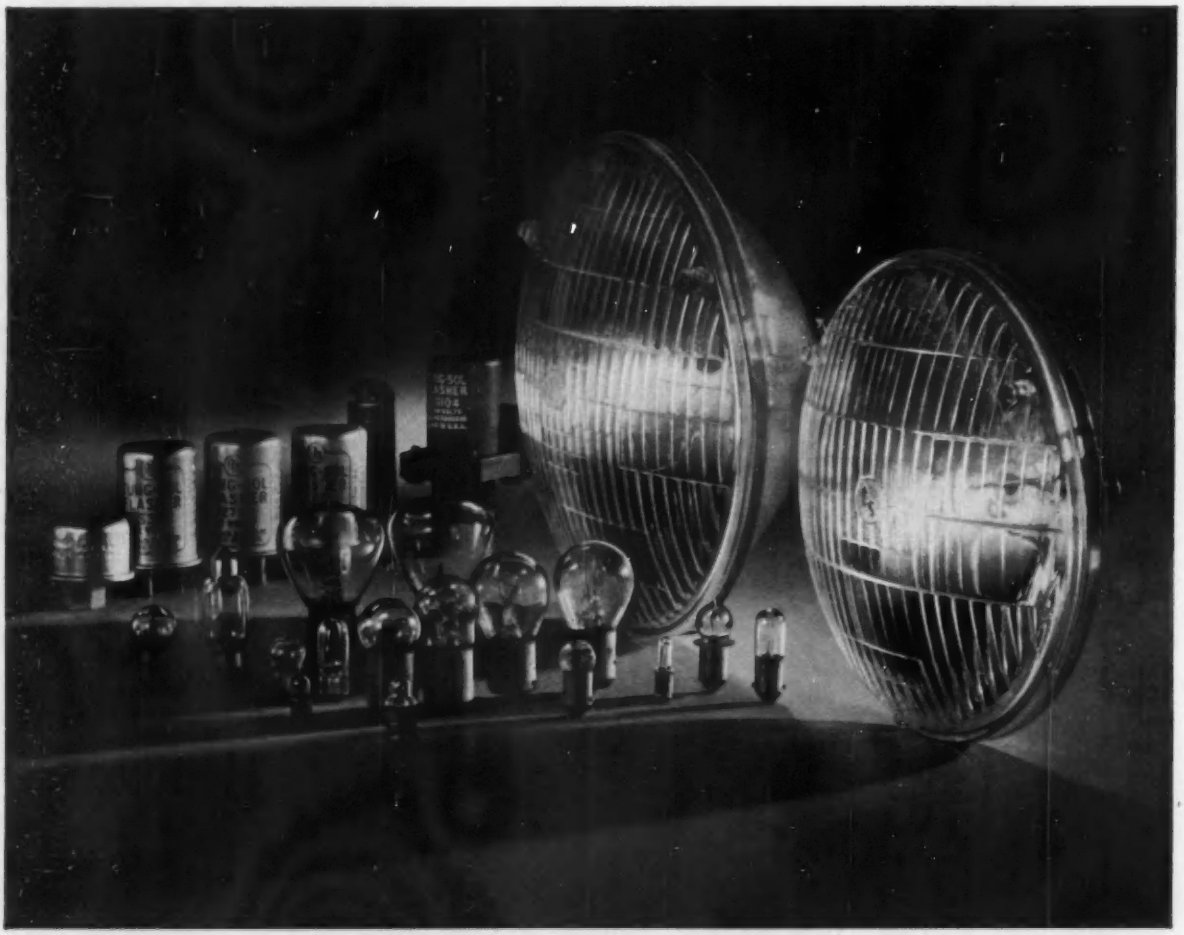

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Briefs of SAE PAPERS

continued from p. 6

in pairs, or as 3- and 4-unit combinations for turnpike operation with one driver and all engines running.

Automatic Transmissions for Diesel Engines, R. M. SCHAEFER. Paper No. 358B. Features comprised in fully automatic transmission concept developed by Allison Div., General Motors Corp. for commercial truck or on-highway hauling equipment are: torque converter, automatic lockup clutch, 6-speed planetary gear train, and hydraulic retarder; key to success of drive proved to be torque converter; economic benefits; adaptation to diesels was possible because of basic principles and concept around which transmission was designed; powered combinations concept.

Diesel Power for Stop and Go Service, J. J. WAYGOOD. Paper No. 358C. Review of differences between diesel and gasoline engines with particular reference to fuel system; relation of fuel economy to per cent of idling and light load operation; maintenance savings resulting from diesel's inherent design advantages; progress achieved by Cummins Engine Co, in releasing new models, JNF-130, developing 130 hp at 2800 rpm, and CF-160 developing 160 hp at 2800 rpm; features that fit dependability requirements of stop and go and at same time reduce initial cost.

Planned Use of Coupled Semitrailers, R. L. DOUGLAS. Paper No. 358D. Summary of experience gained at Eastern Express, Inc., in operation of 3 semitrailers, manufactured by Strick Trailers in Philadelphia; semitrailers are 20 ft-oa length, each complete with single axle and running gear, landing gear, rear doors, lighting and brake system; each semitrailer must be loaded individually, and can be coupled together; general advantages and disadvantages; special advantages in being able to move partial loads and consolidate them into full loads.

Application of Hydrodynamic Drive Units to Passenger Car Automatic Transmissions, E. W. UPTON. Paper No. 359A. Paper is prepared by General Motors Corp. to serve as design reference of current practices as they pertain to passenger cars; fundamental concepts, equations, terminology, General characteristics, and methods for evaluating application are included; laboratory experiments and special problems.

Fluid Couplings, J. W. QUALMAN, E. L. EGBERT. Paper No. 359B. Design requirements of 2-member drive and shifting couplings; 3-member hydrodynamic drive unit, developed by Detroit Transmission Div. of General Motors Corp. has characteristics of fluid coupling and torque converter; it affords supplementation of gear ratio in step gear transmission with good extension of this torque multiplying range; description and operation of basic types in use and design considerations; effects of varying critical factors involved show where departure from basic design may be necessary to accomplish desired objectives.

Multiturbine Torque Converters, F. H. WALKER. Paper No. 359C. Main objective of multiturbine converter developed by Buick Motor Div., of General Motors is to provide transmission requiring no shifts in normal acceleration from stop; characteristics of various geared converter units and how they operate; methods of construction used.

Shaft Design for Finite Lift, P. E. BURKE. Paper No. 359D. Paper attempts to simplify design procedure for shafts for passenger car automatic transmissions; treatment given is primarily for steel shafts loaded in pure torsion, but similar methods can be

continued on p. 129

A. H. SEEBOLD REPORTS...

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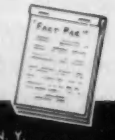

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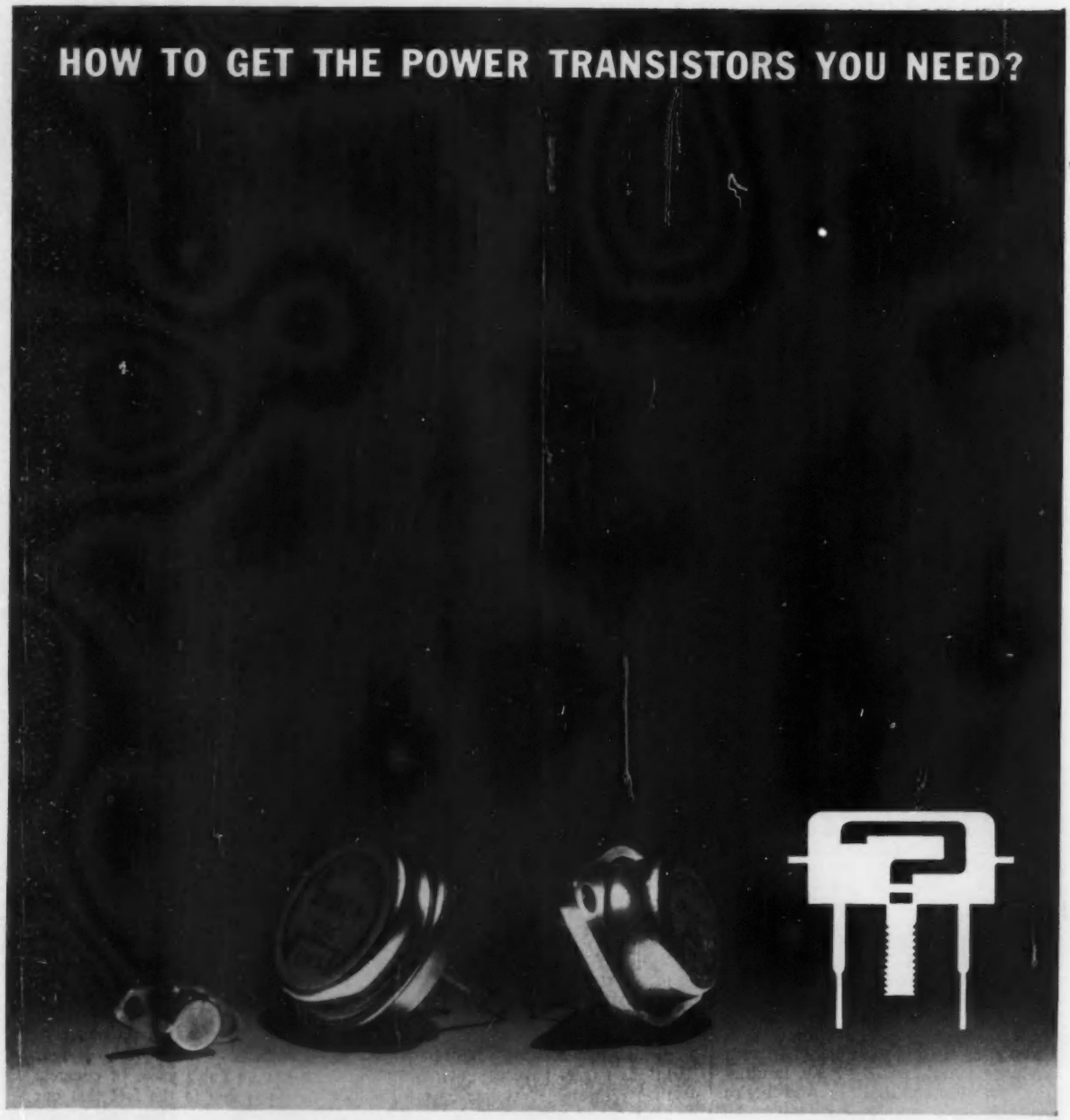

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Briefs of SAE PAPERS

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applied for bending or combined bending and torsion: tabulation of strength properties of steel and prediction of design loads and design life; calculations of nominal stress; method will help designer to evaluate hardness and stress concentration factors and will tend to minimize failures in first prototype designs.

Design of Sleeve Bearings and Plain Thrust Washers on Current Passenger Car Automatic Transmissions, W. A. WEINKAMER. Paper No. 359E. Review of operating conditions with which sleeve bearings and thrust washers must live, pointing out differences in thinking between transmission designers; scientific approach to thrust washer testing is attempted by Cleveland Graphite Bronze, Inc., offering data which show promise of improving performance in operation; thrust washer test machine used, tests undertaken, and results obtained.

Rolling Element Bearings in Passenger Car Automatic Transmissions, R. H. WHITE. Paper No. 359F. Radial bearings in planet gears; calculations are given for load capacity formulas for loose needle rollers, tabulation of planet pin materials, and pinion bearings used in most production transmission in existence today; thrust bearings used in geared section of transmission and torque converter section which is part of transmission package.

Selection of Truck Body and Special Equipment, F. COUSAR. Paper No. 360A. Summary of experience gained at Railway Express Agency, Inc.; selection of materials used in building of body depends on life expectancy, capital funds available for purchase, type of operation, climatic conditions, maintenance procedures; other items requiring consideration from standpoint of efficiency of delivery and minimizing of maintenance are selection of rear doors and side doors, height inside cargo compartment, proper lighting inside vehicles, etc.

Multistop Delevery Selection, W. R. HERFURTH. Paper No. 360B. Problems involved in selection of multistop vehicle weight ratings up to 8000-10,000 lb GVW and objectives of fleet manager to purchase vehicles with as low fuel, oil, and tire expense as is compatible with service, low maintenance cost, adequate speed and grade ability, safe steering and brake control, and low purchase price; approach taken by United Parcel Service is summarized.

Some Considerations in Operation and Maintenance of Multistop Vehicles, J. A. GARFIELR. Paper No. 360C. Plan used by J. L. Hudson Co. in dealing with problems of operation and maintenance; suggestions on cutting costs, determining areas for study, upgrading operations, investigating new ideas and preventive maintenance of existing equipment.

Theoretical and Practical Aspects of Automotive Brake Design and Testing, F. V. KLCO. Paper No. 361A. Major factors which must be considered by designer and engineer in determining required braking performance are gross weight and maximum speed of vehicle; other factors are weight distribution, deceleration requirements, brake effort distribution, brake lining arc of contact, barke lining coefficient of friction, brake pedal effort, and power booster mechanisms; laboratory brake testing and equipment used.

Instrumentation and Method for Evaluation of Variables in Passenger Car Brakes, J. L. WINGE. Paper No. 361B. Examination of variables in brake system in their relation to effects observed in steering wheel and brake pedal; analysis shows that 3 important characteristics require careful consideration: variable coefficient of friction, relative drum and lining radii, and drum and shoe flexibility; empirical methods for evaluation of variables in passenger car brakes, laboratory lining testing machine, and test curves obtained; recommendations made.

New Concept of Measuring Frictional Characteristics, G. R. SMITH, V. J. JANDASEK, S. R. SPRAGUE, R. B. SINGER. Paper No. 363A. Proposal for testing of wet friction characteristics in automatic transmission was formulated by subcommittee selected from transmission and friction material manufacturers, and oil industry; basic requirements and development of procedure for running of friction test, based on determination of date under steady state conditions; other conditions which are fixed are unit pressure on friction surface and temperature; test results obtained.

Brake Balance, J. R. ALMOND. Paper No. 364A. Brake balancing requires systematic analysis of all brakes in combination of vehicles, but quick analysis vehicle-by-vehicle brake balance, and measure of vehicle brake effectiveness or K factor, can be made with simple equipment and procedure; equipment required and procedure outlined.

Why and How of Rating Commercial Vehicle Brakes, D. P. FISHER. Paper No. 364B. Proposal for concentrated test program, carried out by AMA-TTMA Brake Committee, to develop and finalize rating procedure and

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formula for relating brake rating to VGW; description of vehicle preparation and rating test procedure covering single unit motor vehicles; preparations and rating procedure for trailers and special vehicles; summary of test results.

Research with Respect to Fatal Accident Causes — Implications for vehicle Design, W. HADDON. Paper No. 366A. Problem of annual tool of death and injury which results from nation's use of motor vehicles is considered from viewpoint of medical profession concerned with public health; 4 possible strategies which might lead to reduction of injury and death, modification of vehicle use, legal and engineering measures, prevention of injuries, and provision of emergency and long range care; examples of design modifications which might be made in direction of reducing injury.

Role of Driving Simulation in Vehicle Design, J. VERSACE. Paper No. 366B. Background of driving simulation problem, efforts made, and examples of various devices and simulators involving complete systems; techniques applied, measurements of criteria relative to traffic safety, and value of simulation fidelity.

High-Speed High-Output Diesel Engines — 35 Years of Development of Railroad and Marine Applications, M. von KIENLIN, G. W. MAYBACH. Paper No. 367A. Background of Maybach engine and post war developments; problems pertaining to high engine speed, and research techniques applied to develop Maybach MD tunnel engine; running at speed around 1500 rpm, engines are single acting 4-stroke, ranging from 4- to 16-cyl, built either as in-line or V models, naturally-aspirated or turbocharged; engine performance and turbocharger characteristics. 21 refs.

Ordnance Requirements for Hydraulic Brake Fluid and Rubber Cups, C. F. PICKETT. Paper No. C2. For purposes of discussion, conditions of importance for both hydraulic brake fluids and cups to military can be divided into packaging, standby storage, heavy duty, and arctic operations; requirements in these areas are considered.

Multifuel Engines — Why — How — When by J. C. EMANUEL. Paper No. S303. Discusses the reasoning behind the Ordnance interest in multifuel engines and some of the problems encountered in the design of these engines.

Engineering Tests of Ordnance Vehicles by WILLIAM A. GROSS, JR. Paper No. S304. Describes and illustrates the types of tests to which new items of military automotive equipment are subjected. The results of these tests form the basis of decision for future action — user test, adaption for production, or redesign for improvement.

MATERIALS

System for Estimating Cumulative Fatique Damage by Using Miner Rule Corrected for Residual Stress, C. R. SMITH. Paper No. 353B. Reference made to view by M. MINER and earlier by R. PALMGEN that fatigue damage is cumulative at linear rate, and that therefore damage for one stress level could be added directly to damage at any other level, sum being unity; results of constant level and spectrum type fatigue tests on 7075-T6 rivet lap joints; bending stress correction factors.

MISCELLANEOUS

Problems of Installation and Operation of Gas Turbines in Small Boats by W. A. TEWES, JR. Paper No. S306. Describes typical installa-

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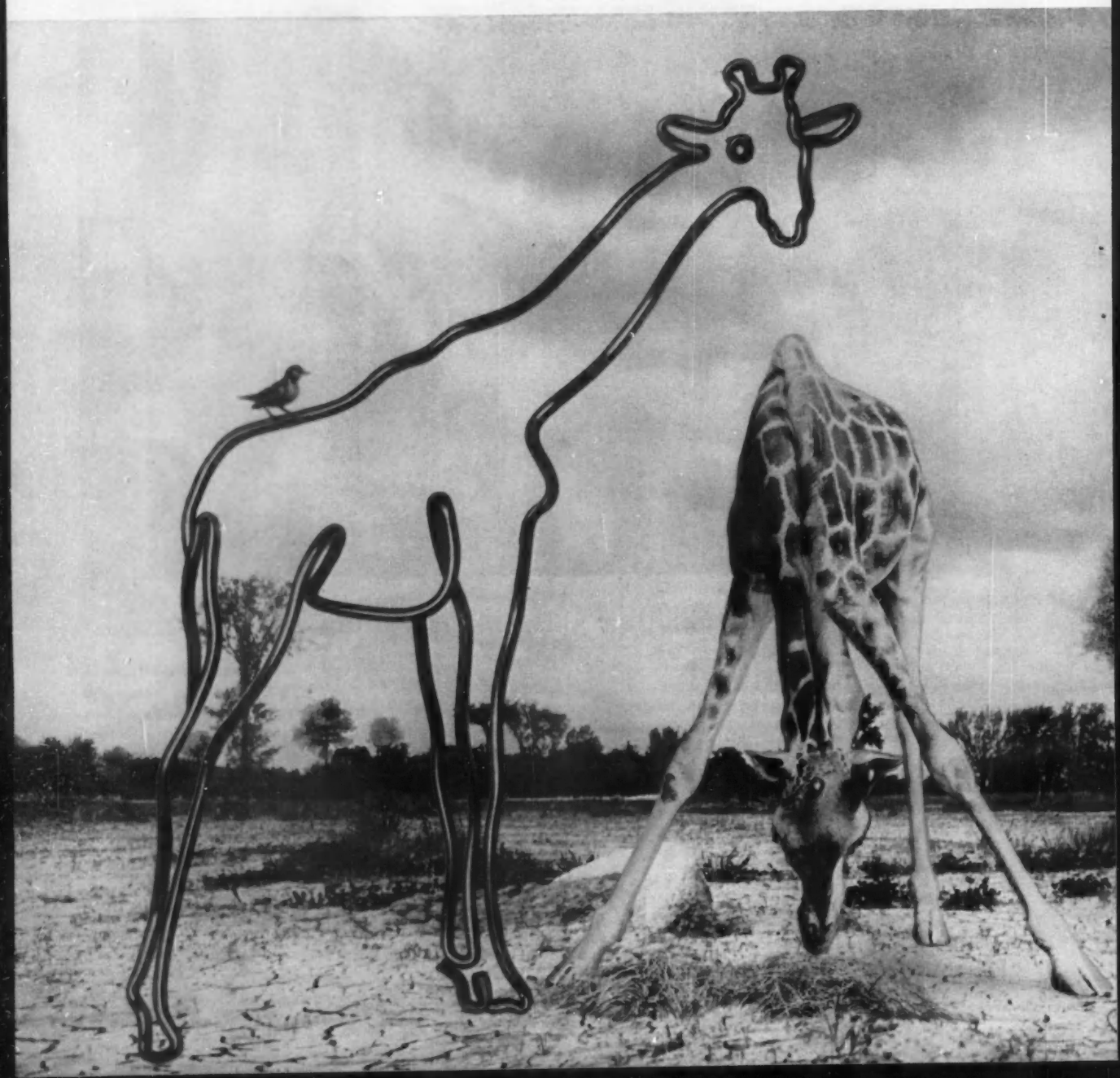

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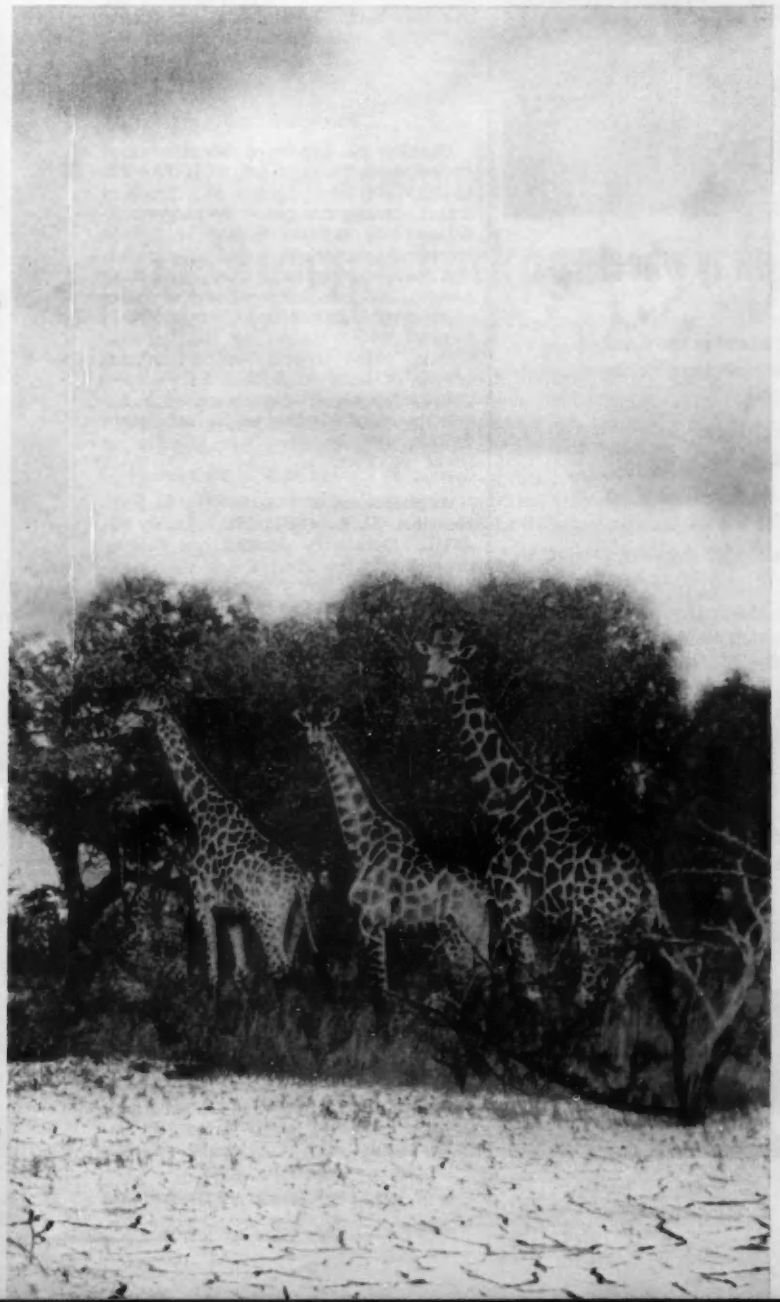

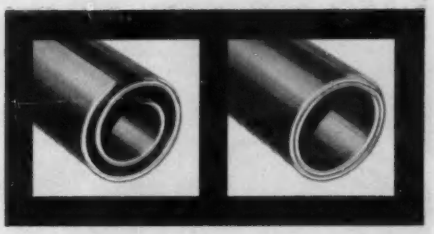

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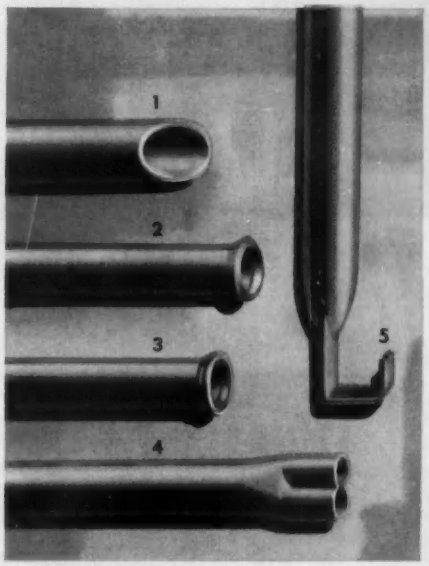

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continued from p. 130

tions of small gas turbines in a Navy 33-ft plastic hull and a 28-ft personnel boat. Methods of quieting and cooling the engine and the effect of exhaust and inlet duct design on turbine output are included.

Fish Propulsion by JOHN HARRISON. Paper No. S307. Reviews the literature on the subject of fish propulsion and summarizes the salient features which allow fish to swim silently at high speeds. Discusses the anomaly between potential energy output of fish muscle compared to the amount of energy required to propel the fish through the water.

PRODUCTION

Brazing of Sandwich Structures of Columbium Alloys, M. M. SCHWARTZ. Paper No. 340G. Limits to refractory metal brazing are posed by recrystallization and ductile brittle transition temperature, formation of intermetallics between refractory metal and filler metals, and relative weakness of latter at elevated temperatures; temperatures beyond which potential tooling materials cause metal contamination; results of tests conducted on Fansteel No. 82 lap shear specimens, with development of brazing alloys refractory metals can be used for missiles or space vehicles.

Applications of Plasma Arc in Fabrication, R. L. O'BRIEN. Paper No. 340H. Details of plasma arc cutting process and transferred and nontransferred plasma arc torches used; most efficient results were obtained with first type; areas of applications are nonferrous materials, stainless steel, high-strength alloys, carbon steel, and underwater cutting; other plasma arc applications such as plating of rocket nozzles, plasma arc weld surfacing high-temperature wind-tunnel operations where high velocities are required.

Distortion and Residual Surface Stress in Grinding and Milling of High Strength Steels, L. J. HOWIKOWSKI, J. MARANCHIK, JR., M. FIELD. Paper No. 340L. Machinability of steels investigated by Metcut Research Associates Inc. under contract to Aeronautical Div. of Curtiss-Wright Corp.; test data for grinding showed factors producing distortion as result of induced stress involve wheel grade, wheel speed, down feed, and grinding fluid; for milling, it is sharpness of cutter, cutting speed, depth of cut, and cutting fluid affect dulling of cutter; analysis of test results.

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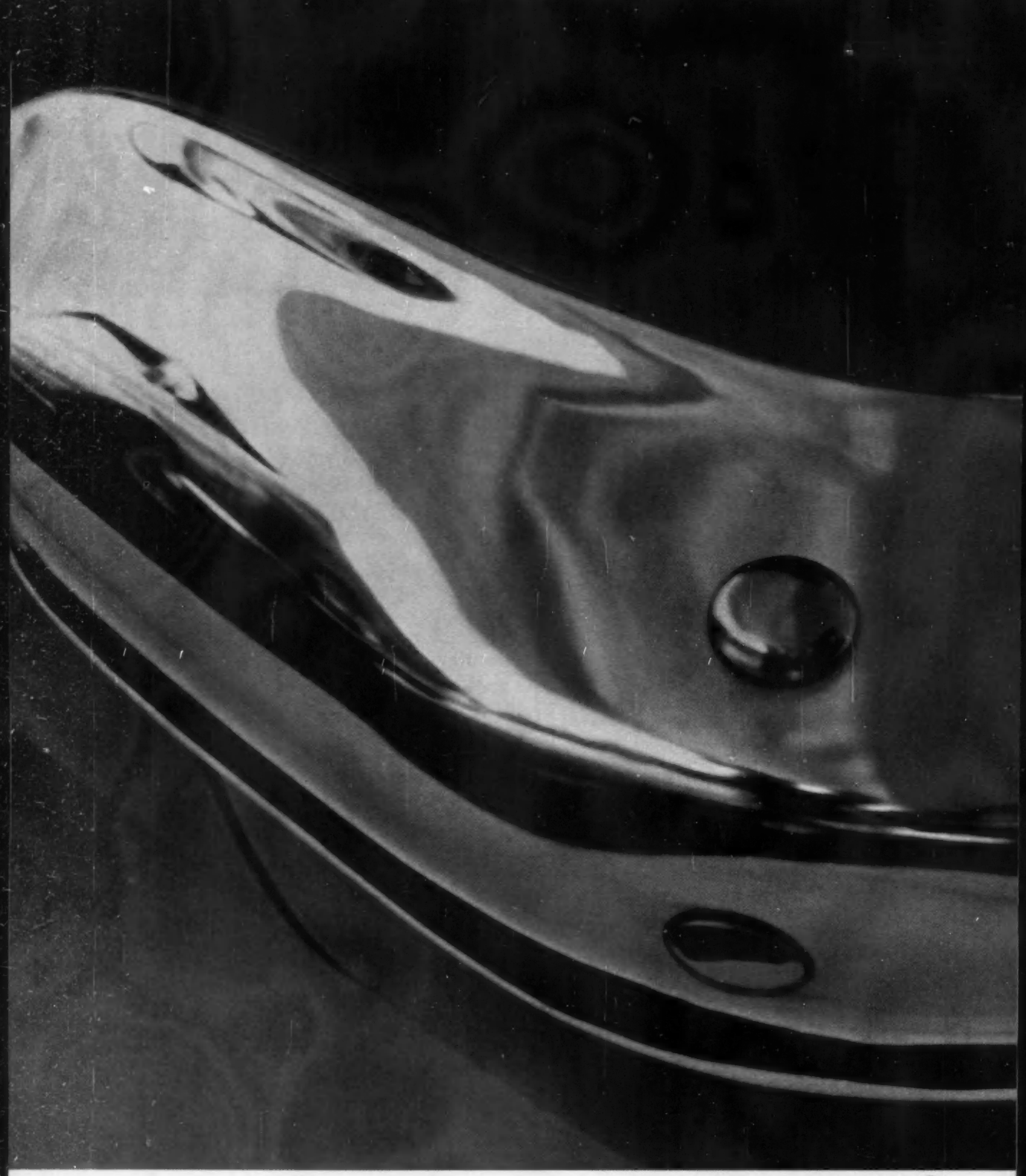

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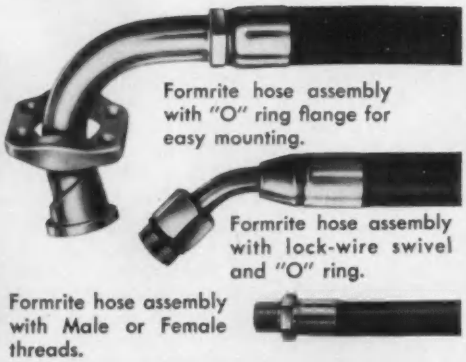

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Milwaukee Section: Lawrence LeRoy Flaugher (M), William Lee Hammer (M), Harvey Lynn Hoy (J).

Montreal Section: James Nicolson Beaton (A).

Northern California Section: Robert Edward Rahtz (M).

Northwest Section: Robert N. Jackson (A), James Henderson Roberts (J), Fred E. Wing, Jr. (J).

Ontario Section: Derrick Henry T. Millard (M), William Edward Silburn (M).

Oregon Section: Ivan Joseph Jones (J), Raymond Wayne Kreman (J).

Philadelphia Section: Walter G. Arnold (A).

Philadelphia Section: Lawrence Adams Botkin (M), Carl William Straits (M).

St. Louis Section: Roger E. Hatton (M), Otto Joseph Muehlbauer (A).

Salt Lake City Group: Clayton Stewart Miller (J).

Southern California Section: Harold D. Diagh (A), A. H. Dunn (M), Richard Irven Hoyal (J), C. K. LeFiell (M), Sidney Anthony Mackin (J), Ted Maier, Jr. (A), James Donald Watson (J), Lewis S. Whitmore (M).

Southern New England Section: Jack Lester Gorr (J), Billie Woodroe Wellman (A).

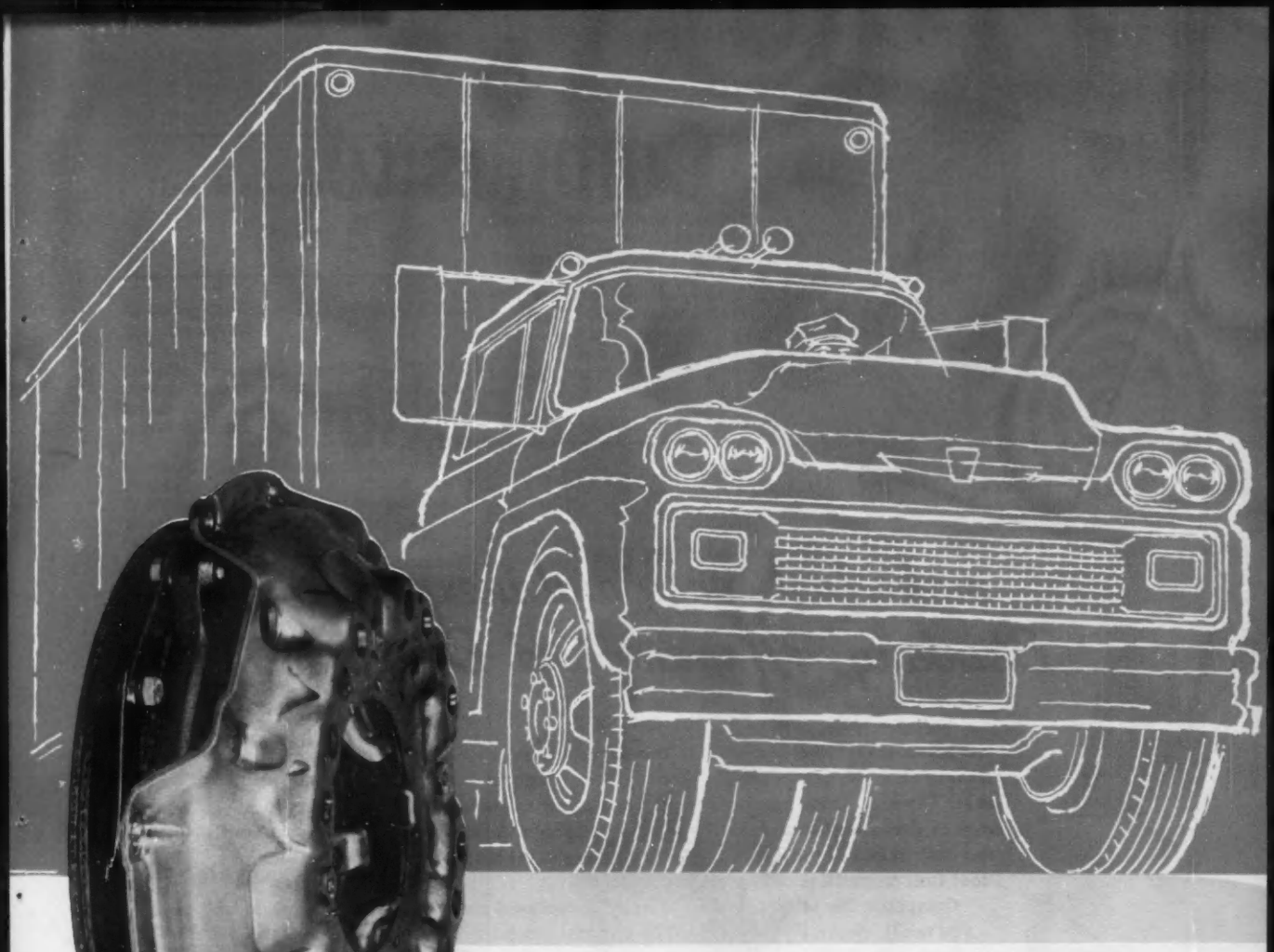
Syracuse Section: John Gustin Lanning (M).

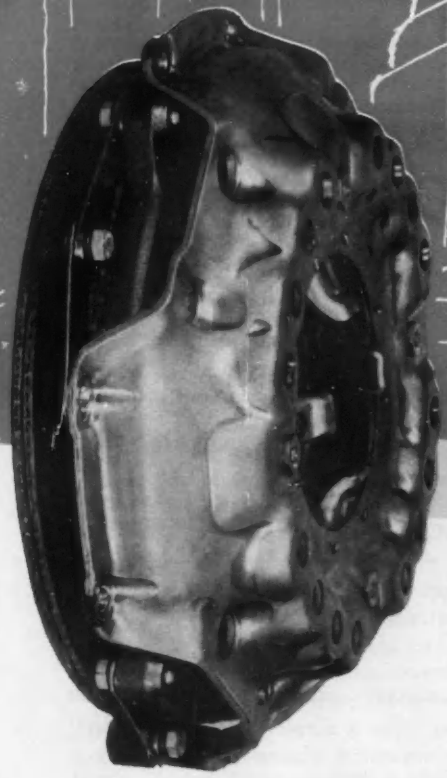
Texas Section: Charles Herbert Allen (M).

Texas Gulf Coast Section: Raymond F. Adams (M), Wayne Hugo Cave (J), W. R. Rotenberry (A), Jack Edgar Spell (J).

Virginia Section: Jan D. Hanrath (A).

continued





New BORG & BECK 2-Plate "Strap-Drive" Clutches

PACK MORE MUSCLE...WITHOUT ADDED SIZE

Trucks pay out on the road, not in the shop. So it's asking for trouble when a truck engine is too big for its clutch.

To help keep 'em rolling, Borg & Beck has developed a new line of 2-plate clutches with up to 40% greater load capacity . . . yet without any increase in nominal size.

Rated at 500 ft.-lbs. torque capacity, this new Borg & Beck Type 13E2 has 12⅞" O.D. x 7¼" I.D. facings . . . non-cushion rigid or flexible center drive plate . . . space for 16 heat treated coil springs of total load to suit type of service . . . "strap drive" for positive, trouble-free plate separation.

And like all Borg & Beck clutches, Type 13E2 is built to Borg & Beck's pace-setting standards for quality, performance and value. Consult our engineers for details.

See our exhibit at the 1961 SAE Heavy Duty Vehicle Meeting and Display Milwaukee — Sept. 11-14

BORG & BECK CLUTCH — THE STANDARD

Reg. U.S. Pat. Off.

BORG & BECK B-W DIVISION BORG-WARNER

BORG & BECK®

THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3

Composite Die Sections

make fast, easy and inexpensive Blanking, Trimming and Beading Dies

To save valuable tool steel and to make equally substantial savings in costly diemaking time, use Composite Die sections from Allegheny Ludlum's Forging and Casting Division. These prefabricated die parts come in a wide . . . almost limitless . . . range of sizes and shapes. And they are easy to specify. A simple sketch with dimensions and descriptions of the work to be done brings you the shapes, heights, and grades of tool steel to match your requirements exactly.

Composite Die sections consist of fine A-L tool steel cutting edges (in all the grades you need), electrically butt welded by a special process to nonhardenable mild steel bases. Exact control of temperatures during welding and annealing gives you a bond that will not let go even under the most severe conditions.

Check these many advantages you get with Composite Die sections: You use less tool steel in your dies, and there is much less waste than with bar stock. Screw and dowel holes are easily drilled after the tool steel has been machined and heat treated—because the mild steel bases remain soft. Dowels are easier to fit, too. The back up style of assembly is not needed. Because the tool steel is reinforced and held securely by machine steel base, there is no cracking of sharp corners or long projections. There is less chance of distortion during hardening with A-L composite sections. And any slight warpage may be easily corrected without damage. You get firm, positive fit of sections on die shoes.

Salvage possibilities are also important—sections from obsolete dies can often be reused on new jobs.

Both straight and shaped sections are available with supporting ribs as needed. For more information on Composite Die sections refer to booklet FC4, a 28-page description which also covers smooth hammered **Forgings** and **Cast-To-Shape** tool steels. Ask your A-L representative for your free copy, or write: ***Forging and Casting Division, Allegheny Ludlum Steel Corporation, Ferndale, Detroit 20, Michigan, Address Dept. SA-9.***

ALLEGHENY LUDLUM
FORGING AND CASTING DIVISION

3292

New Members Qualified

continued

Washington Section: Wilson Cross Shepheard (M).

Outside Section Territory: Charles Joseph Baumann (J), Clifford James Beam (J), Royce B. Boykin (M), Raymond S. Poppe (M).

Foreign: Pierre Etienne Bessiere (M), France; Gerard Mervyn Cutler (M), England; Richard Henry Holland (A), Western Australia; Captain Jaswant Singh Maun (M), India; Maurice Subit (M), France; William Gordon Turnbull (M), Australia; Yves Jean van Delft (M), Belgium; Franz Josef Von Bomhard (M), Germany.

■

Applications Received

The applications for membership received between June 22, 1961 and July 22, 1961 are listed below.

Alberta Group: Reinhard Herbert Krentz, Edward Franklyn Symons

Baltimore Section: Silas M. Brown

British Columbia Section: William Hardy McQueen

Buffalo Section: Howard B. Barber, James Thomas Flower, Robert James Kolkmeyer, Donald William Winfield

Chicago Section: George Otto Krueger, Joseph Patrick Nigro

Cincinnati Section: Walter Clifton Gorham

Cleveland Section: Harold W. Schrock, Robert Edward Wilbert

Dayton Section: James Alan Finfrock

Detroit Section: William Lawrence Beat, John H. Bins, Wesley Marion Dick, Curtis Bryan Joyner, Jr., Kenneth Guy Kamm, Richard Henry Kamm, John Anthony Kayser, Donald Walter Kroll, William Fredrick Kruckeberg, Robert Loel Maloney, John J. Mikton, Arthur Larve Plinski, Ray E. Roberts, Gustaaf August Vander Waerden, G. Sheldon Veil, Thomas Floyd Hrynik

Indiana Section: Charles Fredrick Draut, Donald Gene Slane

Kansas City Section: Roy A. Henke

Metropolitan Section: Donald Stephen Deskey, Robert Norman Farkas, James Norwood Fleck, Ronald Sherratt Gall, Charles Gallo, Kenneth Joseph Mackintosh, James B. McKinney, Arnold Sayetta

Mid-Continent Section: Frank Willi Murphy

Milwaukee Section: Herbert Thomas Roedel

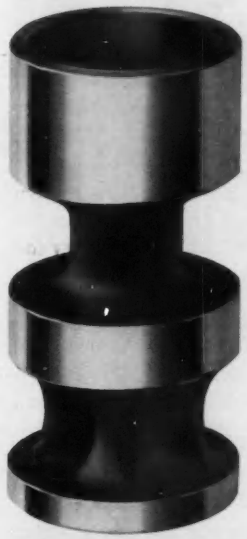
Montreal Section: Harry Hill, David Victor Makuch

Northern California Section: John Sterling McClure

Northwest Section: James Willard

continued

NEW!



Johnson TAPPETS

SKEL KAST

This latest tappet improvement represents still another advancement brought about by the constant search for better design, materials, and manufacturing methods at Johnson Products. The reason? *Better tappets are our only concern.* We welcome the opportunity to put our engineering and test facilities at your disposal. Johnson Products Inc., Muskegon, Michigan.

If you're headed for a product requiring magnets ...consider CeraMAGNET®

The road leading to a new product may be filled with detours where conventional magnets are concerned. That's where Stackpole Ceramagnet permanent magnets warrant prompt and serious consideration. By providing important characteristics, to extents unobtainable in metallic units, they pave the way to many new and unusual design and engineering approaches.

Ceramagnet's high coercive force permits use without keepers or pole pieces, with many poles on a single flat face, and under other conditions which would quickly demagnetize ordinary units. Moreover, Ceramagnet is chemically inert, electrically non-conductive. Molded from ceramic powders, Ceramagnet permanent magnets can readily be produced economically to practically any size or shape.

For ideas and technical data, write for Ceramagnet Bulletin, Stackpole Carbon Company, St. Marys, Pa.

STACKPOLE CeraMAGNET®

GRAPHITE BEARINGS & SEAL RINGS • ELECTRICAL CONTACTS • ROCKET NOZZLES • VOLTAGE REGULATOR DISCS • PUMP VANES • CHEMICAL ANODES • CERAMIC MAGNETS • WELDING & BRAZING TIPS • FERRITE CORES • FIXED & VARIABLE COMPOSITION RESISTORS • SLIDE & SNAP SWITCHES • AND MANY OTHER CARBON, GRAPHITE AND ELECTRONIC PRODUCTS

Applications Received

continued

Hathaway, Robert Evan MacGilvra

Ontario Section: Douglas H. Bates, Paul Charles Cantin, Robert Lynn Curtis, George Donald Doresco, Gordon H. Hinder, Erie Hollingworth, George Elliott Irvine, Charles Edward Kellner, Alfred Jacques Lantagne, Ronald Ernest Magrath, Ian M. McLean, Fernand Edouard Morissette, William Walter Peel, Ernest Richard Perkin, Malcolm R. Ross, Albert Martin Mazur

Oregon Section: Ronald Clare Householder

Philadelphia Section: Carson C. Bitner, G. R. Dunton, III, William Howard Moore, Jr.

Pittsburgh Section: Ronald Andrew Lichalk

Rockford-Beloit Section: Gene Merlyn Korman

St. Louis Section: Kendall C. Crawford, Thomas Eugene Winter

Southern California Section: Ronald George Anderson, Gordon Seidel Chapman, Billie L. Johnson, Richard Edgar Klein, E. Jack Lancaster, Nathaniel LeVert, Jackson Ramsey McGowen, William Joseph McKearney, Philip Grayon Ruhle

Southern New England Section: David J. Hirschfeld, Robert Norman Libsch, Robert Leslie Ruth

Texas Gulf Coast Section: John Michael Draughon

Twin City Section: Everett Truman Michaelson

Washington Section: Frank Junius Smith

Western Michigan Section: Lyn Krolczyk, Walter Edwin Marietta

Wichita Section: Richard Vern Lewis

Outside Section Territory: Ronald A. Campbell, Robert Frank Jaekel, James Stephen McKarns, Martin Joseph Paul, Roland P. Rebhorn, Elwin J. Salter

Foreign: Haim Alroy, Israel; Malcolm W. Anderson, England; Nils Axel Borglin, Sweden; Paolo Giuseppe Fumarola, Italy; Harold Ernest Jackson, England; William James King, Australia; Srinivasan Muthukrishnan; Rees Oakes, S. Africa; John Hezeward Pitchford, England; Shiv Narayan Shrivastav, India; Satya Narayan Singh, India; Kenneth Donald Stone, England

WHEN MOTOR OIL FLOWS THROUGH THIS NEW FRAM "WEAR-GUARD" OIL FILTER

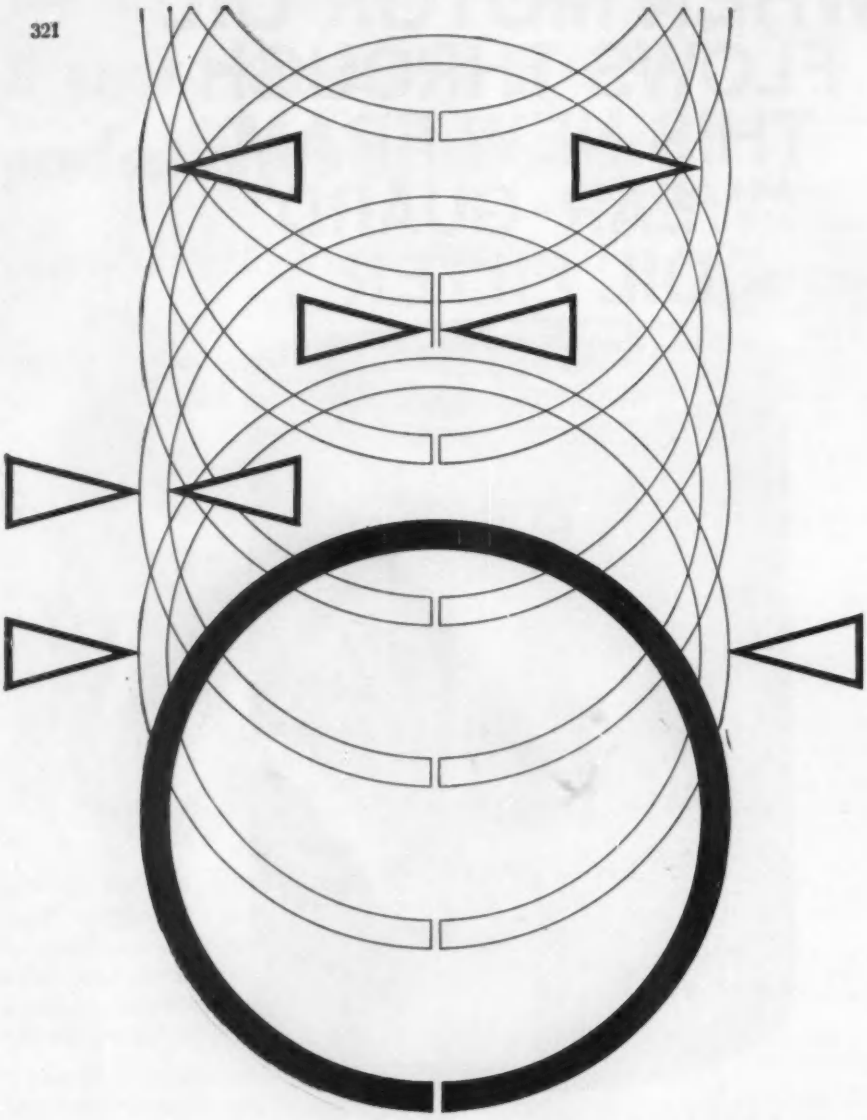
UP TO 40% MORE ENGINE-KILLING SLUDGE IS TRAPPED!

Tests using radioactive tracer techniques proved it! An exclusive scientific breakthrough in the construction of new Fram "Wear-Guard" Oil Filters traps up to 40% more sludge than any other filter tested. No wonder in 1961 more auto manufacturers choose Fram to supply original equipment filters than any other filters. May we serve you? Fram Corporation, Providence 16, R.I.

FRAM

"WEAR-GUARD"® FILTERS

321



With a high speed of production – we produce 500 piston rings per minute – at the same time maintaining fully controlled precision as a prime feature of our work.

Goetzewerke
Friedrich Goetze A G
Burscheid bei Köln
Western Germany

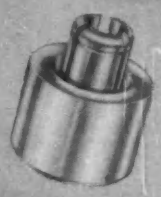
HOW MANY WAYS CAN *Special Purpose Fasteners* CUT COSTS FOR YOU?

How many of your products employ laborious, old-fashioned fastening methods where simple fasteners could do the job and cut costs, too? How many parts and sub-assemblies can be adapted to include a self-fastening feature? How many future products could be improved by advance planning for fastener efficiency?

United-Carr's engineering staff offers you a wealth of experience in the design of special-purpose fasteners and self-fastening devices. Large-scale manufacturing facilities (including in-plant plastics molding equipment) ensure economical, *volume* production and prompt deliveries. United-Carr field representatives are ready to call on you at *your* request.

The names DOT, TEENUTS, TRIMOUNT are registered trade-marks of United-Carr Fastener Corporation

POLYETHYLENE MOUNTING FOOT



No mar, no scratch glide for use on TV receivers, record changers, small appliances, etc. Assembles into round hole in wood or metal cabinets.

NYLON SNAP-IN NUT

Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

QUICKEY FASTENER

Eliminates need for welding or swaging studs to sheet metal stampings, facilitates nesting, eliminates damage in transit because Quickey snaps in before final assembly.

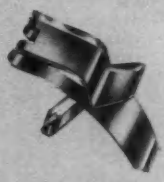
6-PRONG TEENUT

Offers greatly increased push-out resistance; virtually eliminates the problem of lost fasteners, cuts rejections, customer complaints, etc. Claw-like prongs toe in for maximum gripping power.

PLUG BUTTONS

Snap into ⅛" to 3" dia. holes. Can be embossed with ornamental or functional designs . . . various finishes, shapes and sizes.

WIRING FASTENER



Mounting legs snap into round hole . . . provide secure anchorage. Body of fastener holds wires without chafing.

MOLDING FASTENER

Ideal for use with thread cutting fasteners or available with threaded stud for nut and lock washer assembly. Spring leg maintains tension to keep fastener blade locked in molding channels.

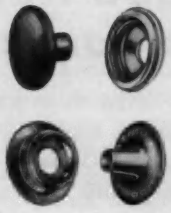
TEENUT

One-piece, all-metal nut has welding bosses on upper or lower surface of mounting flange. Has high tensile strength and provides secure, permanent anchorage for bolt. Available in various shapes and sizes.

TRIMOUNT STUDS

Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration-proof attachment. Permanent or removable. Many shapes and sizes.

DURABLE DOT FASTENER



Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

MAKERS OF ★ DOT ★ PRODUCTS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse

1 HIGH-SPEED OPERATION
Balanced release levers permit high-speed drives. Lever "throwout" is eliminated for longer bearing life. Patented anti-friction rollers give instant release with minimum pedal pressure.

2 ACCURATE FIT
Close-tolerance drive between cover and pressure plate assures smooth starts. Highly accurate bolt circle fits flat flywheels—accurate outside pilot diameter fits counterbored flywheels.

3 VIBRATION DAMPENER
Coil-spring vibration dampener absorbs vibrations between engine and transmission. Noise, rattle and thrash in the gear train are eliminated for smooth, quiet clutch operation.

ROCKFORD SPRING-LOADED CLUTCH

International model C-130 Dump Truck equipped with Rockford Spring-Loaded Clutch

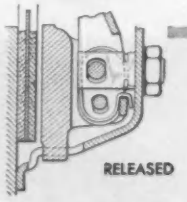
See us at the Milwaukee SAE Show Sept. 11 to 14

4 HIGH-TORQUE DESIGN
Powerful engagement springs, properly spaced over the facing area, assure maximum driving contact. Compact, low-inertia design prevents gear clashing and delayed shifting.

5 SMOOTH ENGAGEMENTS
Dynamic and static balancing assures you of smooth, enduring clutch performance. Both driving and driven members are balanced to eliminate vibration.

6 HIGH-TEST FACINGS
Using only the highest quality facings, Rockford Clutches give extra-long clutch life, provide cushioned starts, reduce scoring and greatly cut costs of downtime replacement and labor.

7 PERFECT ALIGNMENT
Close-tolerance splined hub assures perfect disc alignment. Through-hardened hub gives long life. Precision manufacturing and rigid quality control eliminate chances for misalignment.



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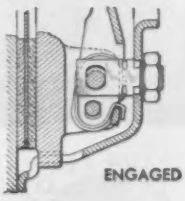

ENGAGED

7 Good Reasons Why Idea-Men Count on Rockford Reliability

Above are seven reasons why more and more design men specify Rockford Spring-Loaded Clutches. Equally important, ROCKFORD RELIABILITY is due to 63 years of creative engineering, precision manufacturing and rigid quality control. Rockford offers complete design engineering service at no cost or obligation. You're backed by a worldwide service network. Write today for complete details on ROCKFORD RELIABILITY.

ROCKFORD CLUTCH

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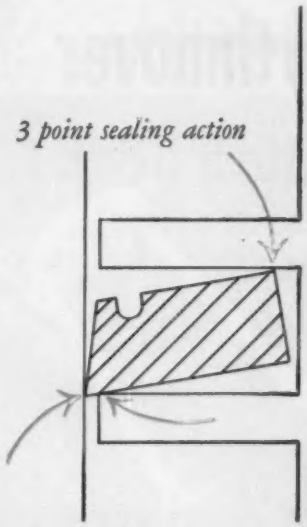
Export Sales Borg-Warner International • 36 So. Wabash, Chicago, Ill.

ROCKFORD B-W CLUTCH

DIVISION OF BORG-WARNER



new, for high vacuum engine compression and oil control—

UNISEAL COMPRESSION RING

REVERSE TORSION

A new concept in reverse torsion compression rings is now available in the form of a one-piece, cast iron ring with positive side sealing. This new reverse torsion ring is especially valuable in providing oil control in high vacuum engines. The ring is taper-faced with a front groove on top to achieve reverse torsion. Used in the second groove, it effectively seals oil from below, keeping it out of the groove.

The new Uniseal Compression Ring takes its place in the long line of Ramco Ring developments. You may find some of these particularly interesting to you. Your phone call or letter will bring you the full story.

***Piston Rings by* THOMPSON PRODUCTS RAMCO DIVISION**

Thompson Ramo Wooldridge Inc. • Dept. Q., P. O. Box 513 St. Louis 66, Mo.

TRW

AUTOMOTIVE GROUP

THOMPSON PRODUCTS LIGHT METALS DIVISION | THOMPSON PRODUCTS MICHIGAN DIVISION | THOMPSON PRODUCTS VALVE DIVISION | THOMPSON PRODUCTS RAMCO DIVISION | THOMPSON PRODUCTS MOTOR EQUIPMENT MANUFACTURING DIVISION

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GOODYEAR

Q: What do Goodyear Earthmover Rims have that no others have?

A: MORE times FOUR

1. MORE rims on the job: More tons are hauled on—more earth-moving equipment rides on Goodyear rims than on any other kind. Result: You reap the benefits of the widest, soundest experience in rim design, manufacture and use.

2. MORE kinds of rims: Maximum rim performance stems from proper specification. Goodyear makes the *only complete line* of earthmover rims. Result: The choice that permits you to get exactly the right rim for the job.

3. MORE rim engineering help: Goodyear has more engineers designing *and selling* rims than any other company. And they know tires, too. Result: The help you need in choosing the right rim for top performance—longer tire life.

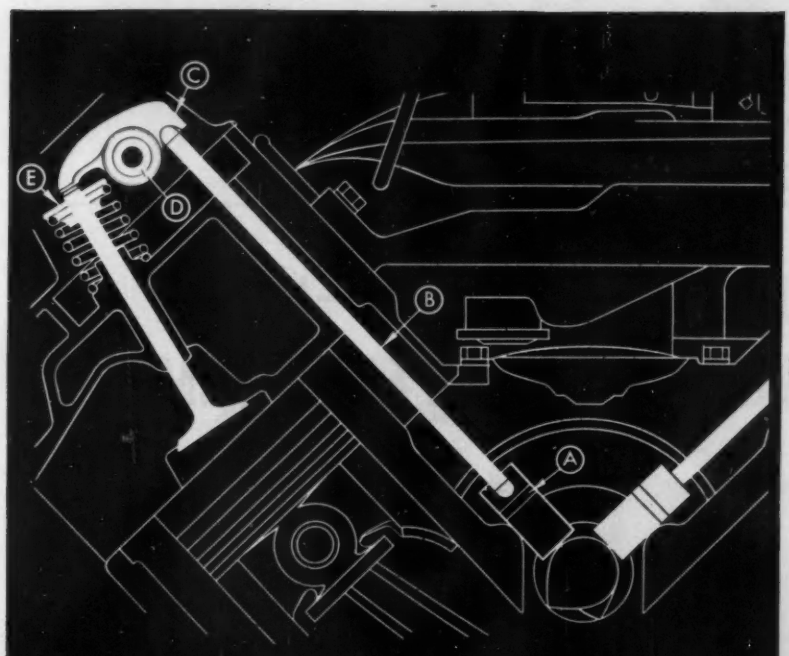
4. MORE rim "firsts": The first *true* earthmover rim, the first 5° rim, the first tubeless rim—in fact, every major earthmover rim advance was made by Goodyear. Result: The very latest in rim design and manufacture at work, for you.

What better reasons for choosing Goodyear as your rim supplier? Only these: The desire and ability to design and build any rim that may be needed for *tomorrow's* earth-moving equipment. No matter what your rim needs or plans, you'll find it pays to call on Goodyear. See your local rim distributor, or write: Goodyear, Metal Products Division, Akron 16, Ohio.

Lots of good things come from

GOODYEAR

For all engines - - -



Chicago valve train parts in a typical V-8 automotive engine: (A) Hydraulic tappet, (B) push rod, (C) rocker arm, (D) rocker shaft, (E) valve spring retainer.

Passenger cars

Trucks

Tractors

Diesels

Aircraft

Everything you need in valve gear

from CHICAGO

Here at Chicago you'll find a single source for everything you need in valve gear. These specialized facilities are solving problems and saving money for leading engine manufacturers . . . and can do the same for you.

Design and Engineering—at Chicago you'll find valve gear engineering experience in depth . . . men who understand your problems and will work with your engineering staff in designing cam shafts and complete valve gear assemblies for any type of engine.

Manufacturing—Chicago is a leading manufacturer of valve train parts. Our complete line includes precision-made hydraulic and mechanical tappets; push rods in both lightweight tubular and solid styles; valve adjusting screws including new self-locking screws that cut assembly costs; valve spring retainers; rocker arms and rocker shafts.

Testing—we have complete laboratory and engine testing facilities.

For the full story of how we can serve you, write our Tappet Division.

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872

2701 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

One in a series of technical reports by Bower

BEARING BRIEFINGS

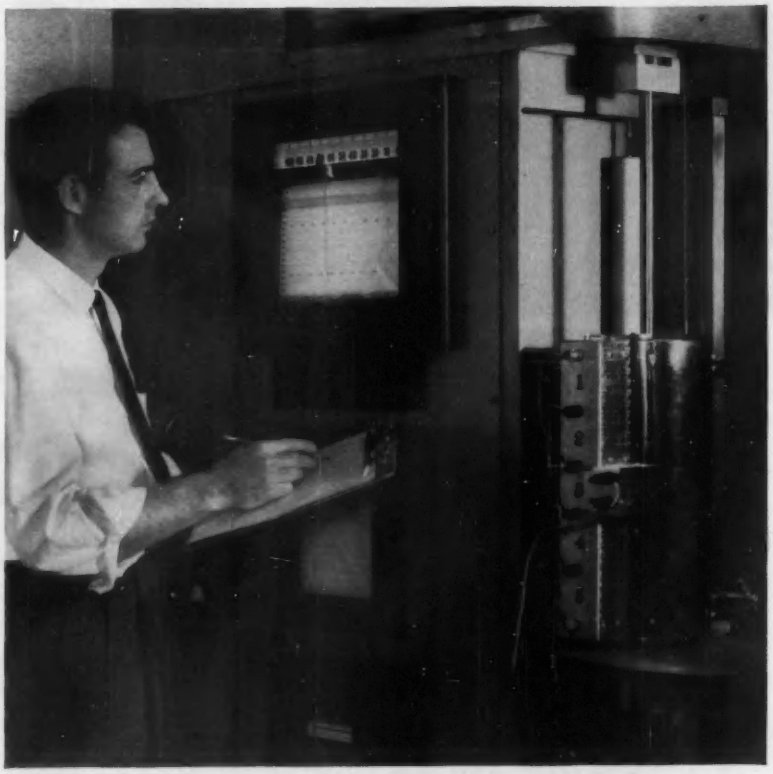
TESTING PUTS THE HEAT ON—HELPS BEARINGS BEHAVE IN EXTREME ENVIRONMENTS

In industry today, bearing operating conditions are becoming increasingly severe. To conquer difficult environments, heat, corrosion and oxidation, Bower conducts exhaustive research to achieve improved bearing performance. One important area of Bower research, for example, is the development of special alloys to withstand extreme heat. To do this, Bower researchers use special heating apparatus to study hardness, strength and other characteristics of alloys at temperatures in excess of 1000°F.

One of the devices Bower utilizes to assure bearing precision at high temperatures is a creep tester. Bower engineers use it to load a test bar to a predetermined stress level, then, with the assistance of a special heating unit, find out precisely how much the bar stretches as temperatures are elevated to a thousand degrees F., and beyond.

With this type of data and the help of other Bower precision research equipment, engineers can determine alloys that best withstand torrid temperatures. They can also effectively mate thermal expansion characteristics of the various alloys used in roller bearing components and in shafts and housings as well. As a result of this mating, Bower creates bearings that maintain precision in the required temperature ranges and ensures bearings that provide long life, heavy load capacity and high-speed operation.

Because of Bower's continuing research in bearing alloys and other critical areas, we suggest you consider Bower to assist you with your bearing needs. Bower provides a full range of types and sizes in tapered and cylindrical roller bearings as well as in journal roller assemblies. Bower Roller Bearing Division, Detroit 14, Michigan.



Bower engineers study how alloys stretch as temperatures rise in excess of 1000°F., to perfect bearings that can take it.

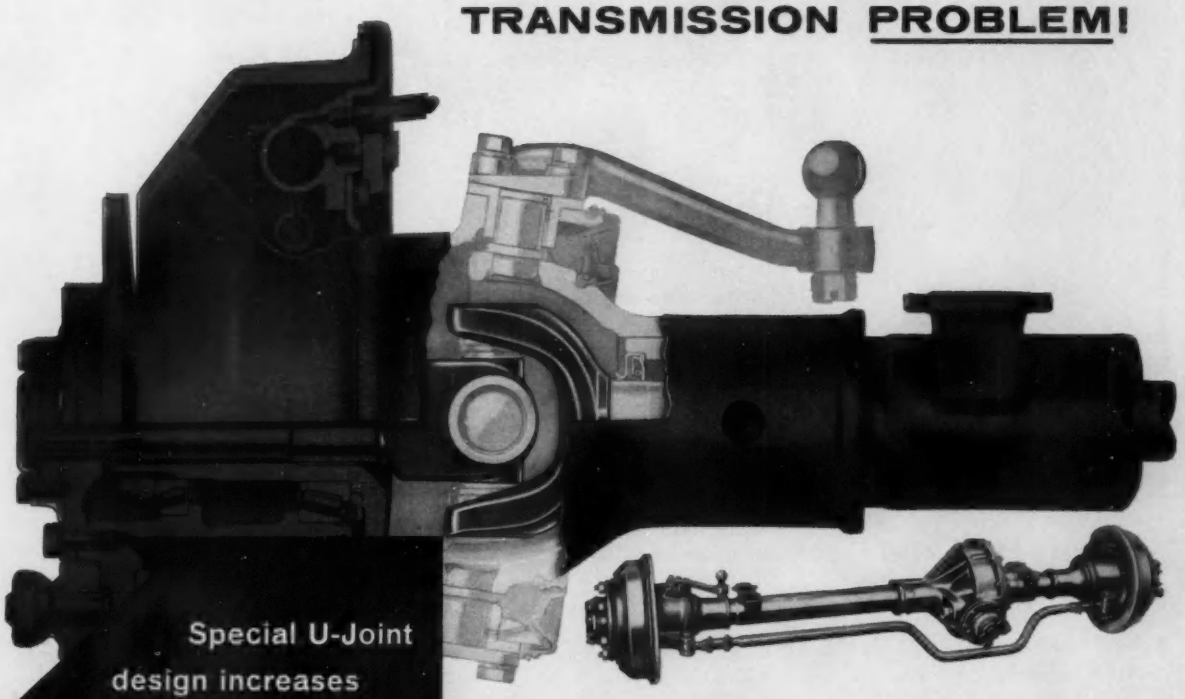
BOWER ROLLER BEARINGS

tapered cylindrical journal

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

BLOOD BROTHERS UNIVERSAL JOINT

SOLVES ANOTHER POWER TRANSMISSION PROBLEM!



Special U-Joint design increases axle torque capacity... yet lowers axle production costs!

Working with a major manufacturer of truck axles, Rockwell-Standard engineers developed a new design for a front steering, driving axle that uses a single carden universal joint in place of the expensive and complicated constant velocity type previously used on a special all-wheel-drive vehicle.

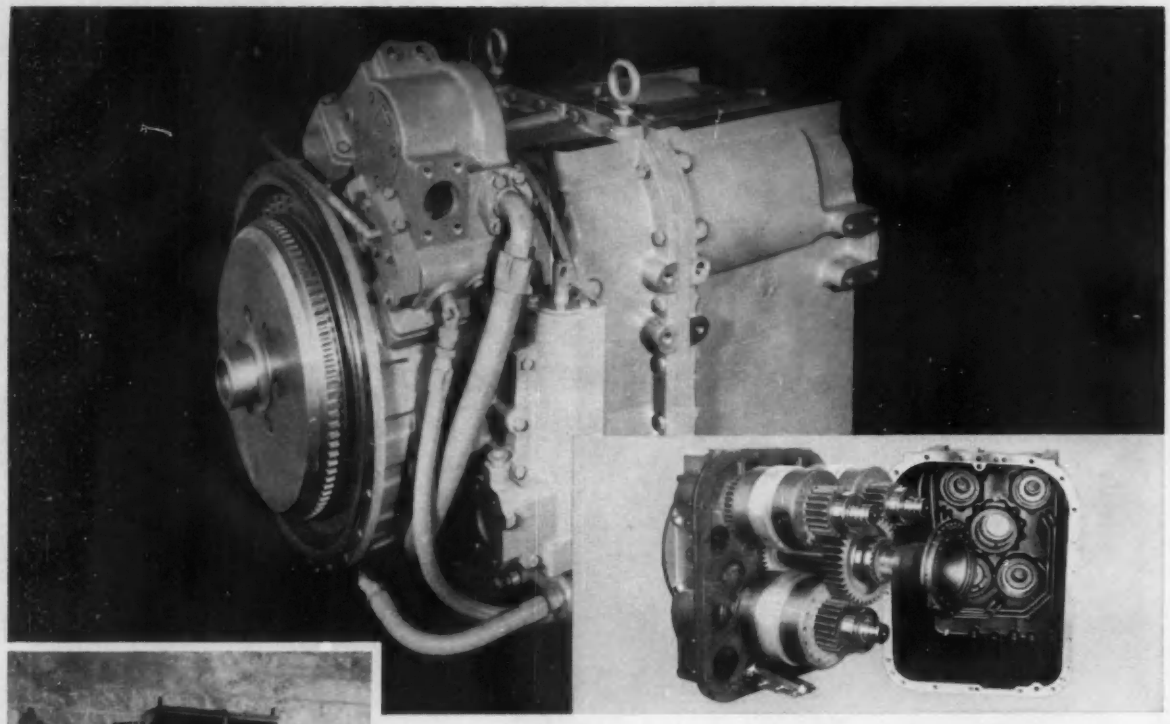
The result: *An axle that provides substantially increased torque capacity . . . at a considerable savings in manufacturing costs!*

Whether you are designing a new product or seeking to improve an existing one, consult Rockwell-Standard engineers for specialized help in meeting your universal joint needs. Chances are, a Blood Brothers product will not only increase performance – but save you time and money as well.

For further product information write for Bulletin

Another Product of...

ROCKWELL-STANDARD
CORPORATION
Universal Joint Division, Allegan, Michigan



TEST REPORT on Twin Disc's New Power-Shift Transmission

Assignment: Hauling copper ore at Arizona mine

At the open pit copper mine of Inspiration Consolidated Company, Inspiration, Arizona, 22 dump trucks work around the clock, seven days a week, to haul out 105,000 tons of ore and 75,000 tons of waste rock. As a test of vehicle endurance, this is about as grueling an operation as you could find anywhere. It was here that Twin Disc's new Series TA-51-2000 Power-Shift Transmission was asked to prove itself.

For testing purposes the transmission was installed in Truck No. 62, a 40-ton Dart 37SL Dump Truck powered with a Cummins NVH-1200 Diesel. This engine produces about 420 net hp (2100 rpm) at the flywheel.

Along with the other 21 trucks in the Inspiration fleet, Truck No. 62 was put to work on the three-mile haul road between pit and crusher.

Result: Six more transmissions ordered

In six months on the job the Twin Disc transmission proved its worth. Regarding its performance, T. M. Anderson, Open Pit Foreman for Inspiration, had this to say:

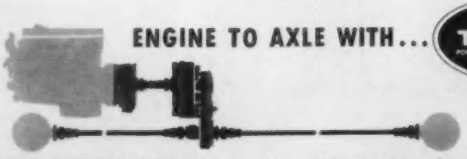
"On the basis of cycle times, fuel efficiency and shifting ease, No. 62 has been beating them all since we put in that new power-shift transmission. The truck pulls away from the loading shovel in third converter drive and is already in fifth lock-up drive when it hits the grade."

As a result of the test model's outstanding performance, Inspiration has already ordered six more Twin Disc Series TA-51-2000 Transmissions.

Twin Disc engineers will be pleased to make application recommendations for your vehicle drive.

Series TA-51-2000, designed for vehicles

- **Three models with ratio spreads of 5.45, 5.93 and 6.80.**
- **Capacities: 420 hp; 1050 lb/ft torque.**
- **Straight-through countershaft design with constant-mesh gearing.**
- **Five forward speeds; one reverse.**
- **Full power-shift in all ranges through oil-actuated clutches.**
- **Engineered as package unit with Twin Disc Single-Stage Torque Converter.**
- **Converter has lock-up clutch on front end to provide direct drive performance when desired.**
- **Hydraulic retarder saves wear on brakes . . . permits safe, controlled descents at higher speeds.**



ENGINE TO AXLE WITH... TWIN DISC

POWER TRANSMISSION EQUIPMENT

TWIN DISC CLUTCH COMPANY, Racine, Wis. (Hydraulic Division) Rockford, Ill.

PROGRESS THROUGH SIMPLICITY

Roosa Master's revolutionary design has made a most significant contribution to the diesel industry. Roosa Master has helped increase engine speed. Roosa Master accessories have helped solve engine manufacture problems. Simplicity of design saved space, lowered costs, and led to progress in diesel engine manufacture. Let us show you how Roosa Master can contribute to your new engine design. Hartford Machine Screw Company, Division of Standard Screw Company, Hartford 2, Connecticut.

Mecha

you can depend on the diesel that depends on HMS ROOSA MASTER

J. I. Case selects two nickel-moly steels for extra endurance in power-train parts

Time is money to the farmer, especially during busy seasons when tractors are on the job from dawn to dark. This Case Model 830 is built to take the long hours of work, year after year, and keep costs *down.*

One reason Case tractors are rugged: Case engineers specify carburized and hardened AISI 4817 and 4620 to provide high strength and toughness in gears and shafts. Here's where:

AISI 4817 (3½% Ni, .25% Mo) is used for the most heavily stressed transmission gears. Readily case carburized and hardened to 60-62 R_C, 4817 develops an extremely strong, tough core to back up the case. With this combination of properties, components handle highest tooth loads, resist spalling, and take impact in stride.

AISI 4620 (1.8% Ni, .25% Mo) is used for spiral bevel pinion and gear in transmission. Specs for these parts require a 60 R_C minimum case hardness plus adequate core strength and toughness to resist impact, fatigue, and torsion.

When you order or design power-train parts, remember that nickel alloy steels provide combinations of properties that mean long, dependable service. For engineering data to help you select the best material for specific applications, write to Inco. We'll be glad to help.

THE INTERNATIONAL NICKEL COMPANY, INC.

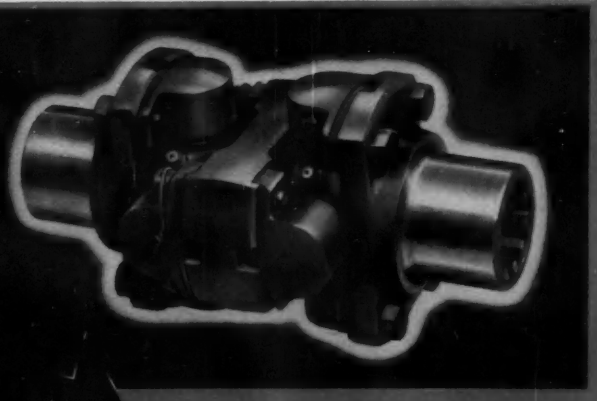
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

MECHANICS

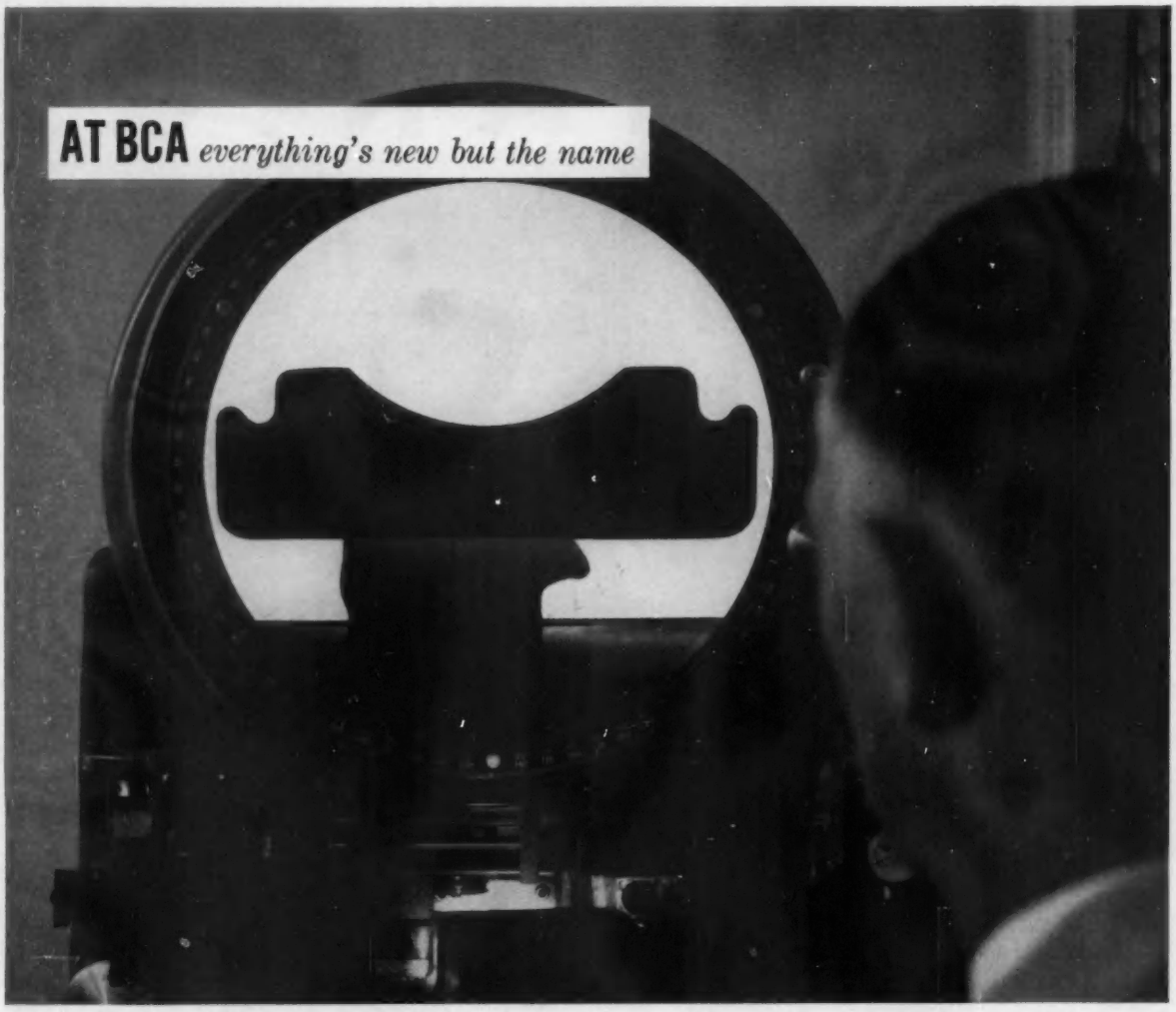
JOINTS MEAN QUALITY FOR YOU



MECHANICS' better quality is the result of constant advances in metallurgy, quality control methods and improved manufacturing methods. Only specially selected steels are used to make MECHANICS Roller Bearing UNIVERSAL JOINTS. Controlled tempering achieves proper hardness. To insure reliable and uniform performance, rigid inspection procedures at every step in the manufacturing process are used at MECHANICS. MECHANICS Roller Bearing UNIVERSAL JOINTS are accurately and durably built for long, heavy service. The proof of MECHANICS' better quality and performance are the millions of MECHANICS Designed Roller Bearing UNIVERSAL JOINTS now in use. MECHANICS JOINTS MEAN QUALITY FOR YOU. Write today for additional information.

MECHANICS UNIVERSAL JOINT DIVISION
BORG-WARNER CORPORATION
2022 HARRISON AVENUE ROCKFORD, ILLINOIS
Export Sales: Borg-Warner International • 36 So. Wabash, Chicago 3, Illinois
Roller Bearing Joints For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Busses and Industrial Equipment •

MECHANICS B-W UNIVERSAL JOINT BORG-WARNER



BIG PICTURE—100 TIMES ACTUAL SIZE—

checks ball bearing geometry

BCA engineers take a close, "big" look at the configuration of inner and outer rings of ball bearings with this contour projector. It magnifies profiles up to 100 times actual size—makes possible extremely accurate measurements and control of all geometric characteristics of raceway rings.

This contour projector provides essential information for BCA research in developing new and modified bearing designs. It also evaluates the production performance of precision tools and machine set-ups by checking the profiles of production raceway rings against precise design specifications. This device is only one of many BCA quality control measures that help assure uniformly high ball bearing quality.

New BCA laboratory facilities also include a variety of specially designed testing machines that simulate actual or exaggerated operating conditions. On this equipment, bearings are studied under exact operating conditions of the customer's application . . . and tested to *exceed* his specifications.

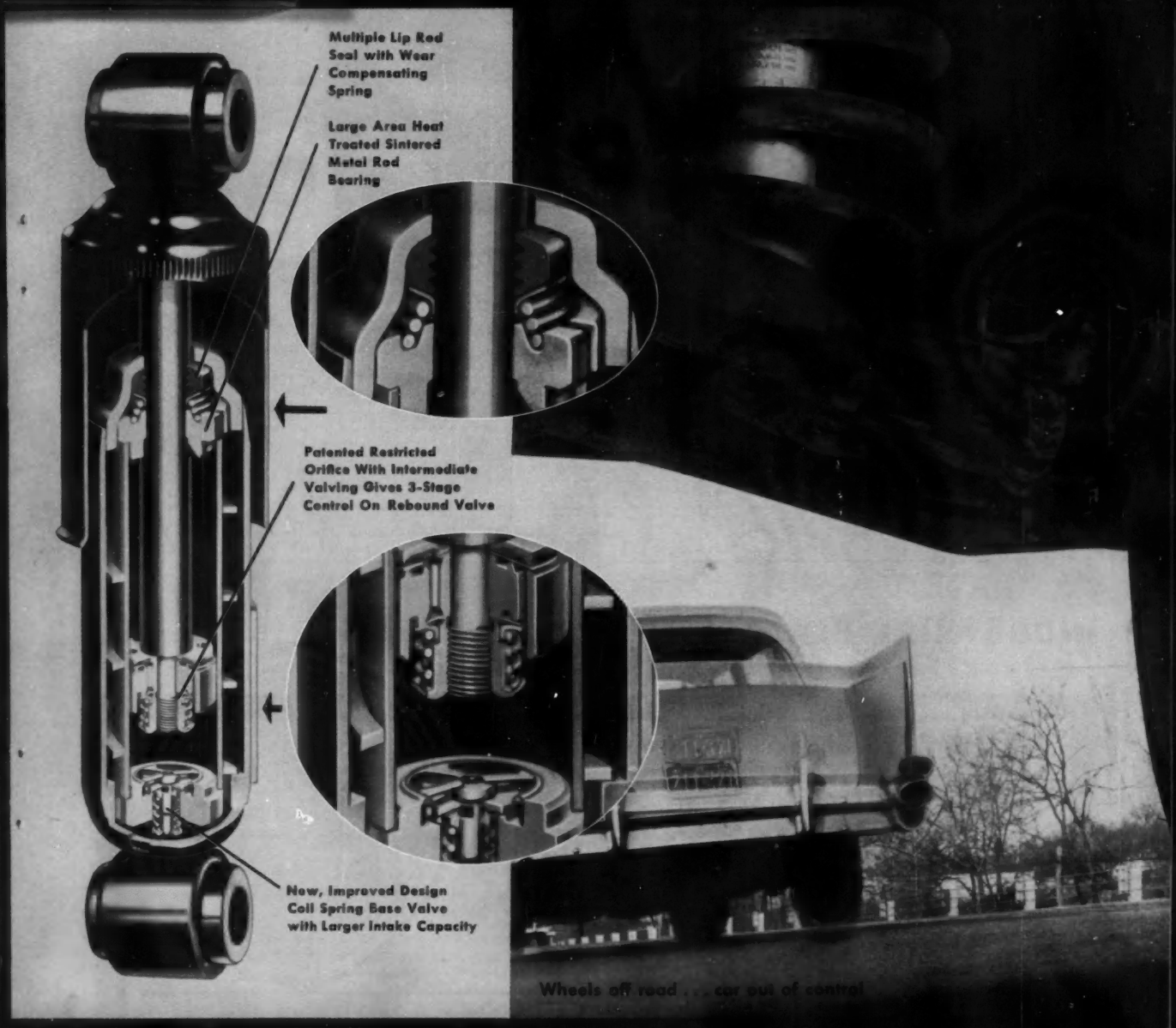
BCA ball bearings for original equipment as well as replacement use are made in a complete range of types and sizes. They serve practically every kind of industry . . . automotive, machine tool, construction and agricultural equipment, to name a few. For complete information, for experienced engineering counsel on bearing applications, contact: Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.


Multiple Lip Rod Seal with Wear Compensating Spring
Large Area Heat Treated Sintered Metal Rod Bearing
Patented Restricted Orifice With Intermediate Valving Gives 3-Stage Control On Rebound Valve
New, Improved Design Coil Spring Base Valve with Larger Intake Capacity
Wheels off road . . . car out of control

Whatever shock absorbers you now specify will probably be replaced by Monroe

Monroe shocks are the miles-ahead leader in shock absorber replacement sales. Why this decided preference?

Ask professional racing drivers, and they'll tell you only Monroe delivers the sensitive, sure-footed control needed to clinch races like the Indianapolis "500". Ask knowledgeable, safety-conscious motorists, and they'll tell you no other shocks provide the road-hugging stability and safety of Monroe.

It's more than likely that car owners will replace the shocks you're now specifying with Monroe when the time comes. Why not give them their preference from the start? Our engineers will be glad to give you facts about Monroe superiority.

MONROE
SHOCK ABSORBERS

MONROE AUTO EQUIPMENT COMPANY • Monroe, Michigan • *World's Largest Maker of Ride Control Products*

POWER STEERING • SWAY BARS • TRACTOR SEATS • SUPER LOAD-LEVELER® (stabilizing units)

BESTWALL INDUSTRIAL GYPSUM PLASTERS

PHYSICAL PROPERTIES	Pouring Consistency (PC)	Setting Time Gillmore Needle Initial	Setting Time Gillmore Needle Final	Setting Expansion % Percent	Setting Expansion Inch Per Inch	Compressive Strength 1 Hour After Set P.S.I.	Compressive Strength Dry P.S.I
Sunflower	68-70	38-50 min.	50-65 min.	.17 to .19	.0017 - .0019	1000-1100	2100-2400
Sunflower L.E.	68-70	38-50 min.	50-65 min.	.09 to .11	.0009 - .0011	1000-1100	2100-2400
Densite K-12	36-37	25-35 min.	35-45 min.	.035 to .045	.00035 - .00045	2500-3000	5600-6300
Densite K-17	43-45	20-30 min.	30-40 min.	.06 to .07	.0006 - .0007	2000-2500	5000-6000
Densite K-20	41-43	30-40 min.	40-50 min.	1.0 to 1.2	.01 - .012	900-1200	2200-2700
Densite K-25	44-46	30-40 min.	40-50 min.	.04 to .05	.0004 - .0005	1900-2400	4800-5800
Tooling Densite	38-40	25-35 min.	35-45 min.	.045 to .060	.00045 - .0006	2500-3000	5600-6300
Breakaway	110-120	40-50 min.	50-60 min.	.09 to .11	.0009 - .0011	60-80	250-350

INDUSTRIAL PLASTERS FOR THE TOOLING INDUSTRY

from the NEW BLUE RAPIDS PLANT

Material	Principal Use	Description
	LOW EXPANSION DENSITES	
Densite K-12	Duplicator Models	Lowest expansion provides great accuracy, high strength and hardness
Tooling Densite	Duplicator Models, Splash Castings, Screeding, Rodding, Loft Template Work	Low expansion; special ingredients insure longest working time of any tooling plaster of comparable set
Densite K-17	Pattern & Model Making	A low expansion, high strength plaster used extensively for Keller patterns
Densite K-25	Pattern & Model Making	Same general characteristics as K-17 but is more plastic and builds up better on splash castings than any other high strength plaster
	HIGH EXPANSION DENSITE	
Densite K-20	Pattern Making	Gives necessary high expansion to patterns when necessary to compensate for shrinkage of aluminum or zinc alloy metals as Kirksite, etc.
	REGULAR MOLDING PLASTER	
Sunflower Molding L.E.	Temporary Patterns Waste Molds	A general purpose tooling plaster. Has lowest expansion of all molding plasters on market. Lower cost than Densites.
	SPECIALTY	
Breakaway	Expendable Mandrels For Forming Plastic Casts	A premium product for formation of irregular ducts and tubes. Immersion in hot water softens the plaster core and permits easy removal. Colored buff for easy identification.

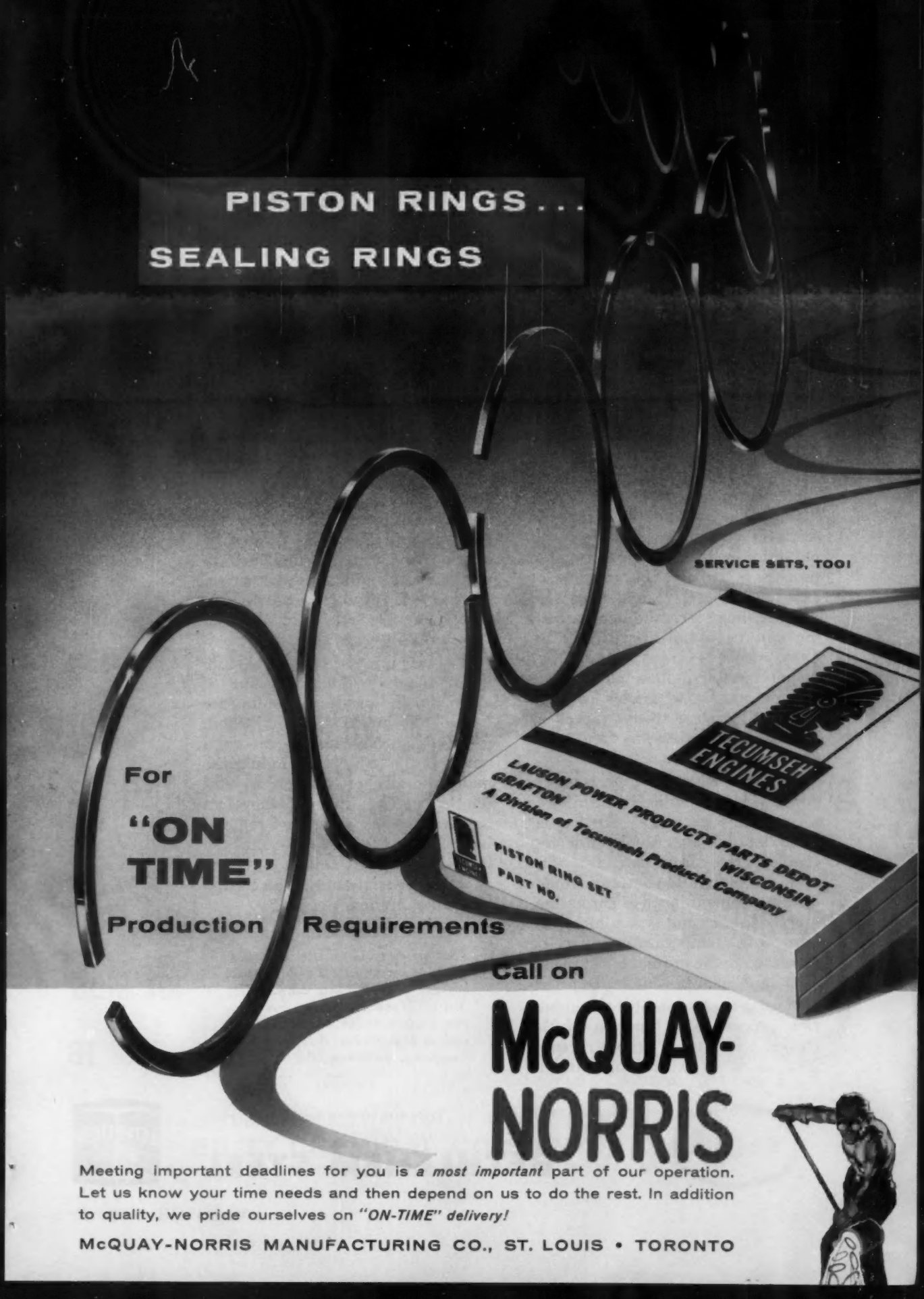
INDUSTRIAL BESTWALL GYPSUM PRODUCTS

BESTWALL GYPSUM COMPANY

Ardmore, Pennsylvania

Plants and offices throughout the United States

FIELD EXPERIENCE + CUSTOMER NEEDS + MODERN RESEARCH + MODERN PLANTS = FULL LINE OF BESTWALL INDUSTRIAL PRODUCTS


PISTON RINGS...
SEALING RINGS
SERVICE SETS, TOO!
TECUMSEH ENGINES
LAUSON POWER PRODUCTS PARTS DEPOT
GRAFTON
WISCONSIN
A Division of Tecumseh Products Company
PISTON RING SET
PART NO.
For
"ON TIME"
Production Requirements
Call on
McQUAY-NORRIS
Meeting important deadlines for you is a most important part of our operation. Let us know your time needs and then depend on us to do the rest. In addition to quality, we pride ourselves on "ON-TIME" delivery!
McQUAY-NORRIS MANUFACTURING CO., ST. LOUIS • TORONTO

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Alloy Steels Respond to Induction Hardening

In the induction-hardening process, steel is first heated above the transformation range by means of electrical induction, then quenched as required. Special equipment is needed, and heat is developed as follows:

High-frequency alternating current passes through a coil or inductor, with the result that a magnetic field is created in the coil. When the piece to be treated is placed in this field, it is heated rapidly by induced energy. With the various types of induction-heating equipment, the process is capable of surface- or case-hardening to various controlled depths; however, through-hardening can be obtained with certain alloy steels. Ferrous metals that respond well to induction hardening include numerous grades of both alloy and carbon steels, as well as hardenable stainless steel and plain or alloyed cast iron.

As a rule, when alloy steels which contain non-carbide-forming elements, such as nickel, are heated by induction, the usual hardening temperatures can be used. But with alloy steels that do contain carbide-forming elements such as chromium, molybdenum, and vanadium, the hardening temperature must be increased if the normal effect of the alloying elements is desired.

Hardness obtained by the induction process is a function of the carbon content and prior structure, just as it is when conventional heating methods are used. Nevertheless, higher surface-hardness values for a given carbon content have often been noted in parts subjected to surface induction-hardening. The extra hardness may be as much as five Rockwell C points for steels of 0.30 pct carbon.

As pointed out previously, the induction method requires special equipment. However, it possesses several marked advantages, including speed of heating and cleanliness of operation. Pieces heated by induction are usually subject to a minimum of scaling and distortion. Moreover, induction-hardening equipment is very compact and therefore conserves floor space.

If you would care to know more about the induction hardening of alloy steels, please communicate with our technical staff. Bethlehem metallurgists have made a thorough study of the subject, including the many details of quenching and tempering. Call them if they can help you in any way. And remember, too, that Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Steel

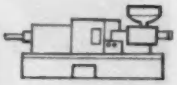
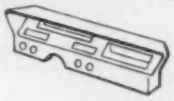
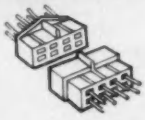
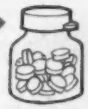
for Strength . . . Economy . . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

What's News In Plastics...

Escon® polypropylene offers molders  a balanced combination of properties for a wide range of molding applications such as high strength and impact resistance in automobile dash boards  ...excellent electrical properties for cable connectors  ...high heat distortion temperature in vaporizers ...low water pick-up in distributor caps ... outstanding dynamic fatigue resistance for "living hinge" in accelerator pedals and snap-fit closures  for containers...outstanding chemical resistance plus high gloss, surface hardness, and quality "feel" in dinnerware . All available for volume production at low cost.

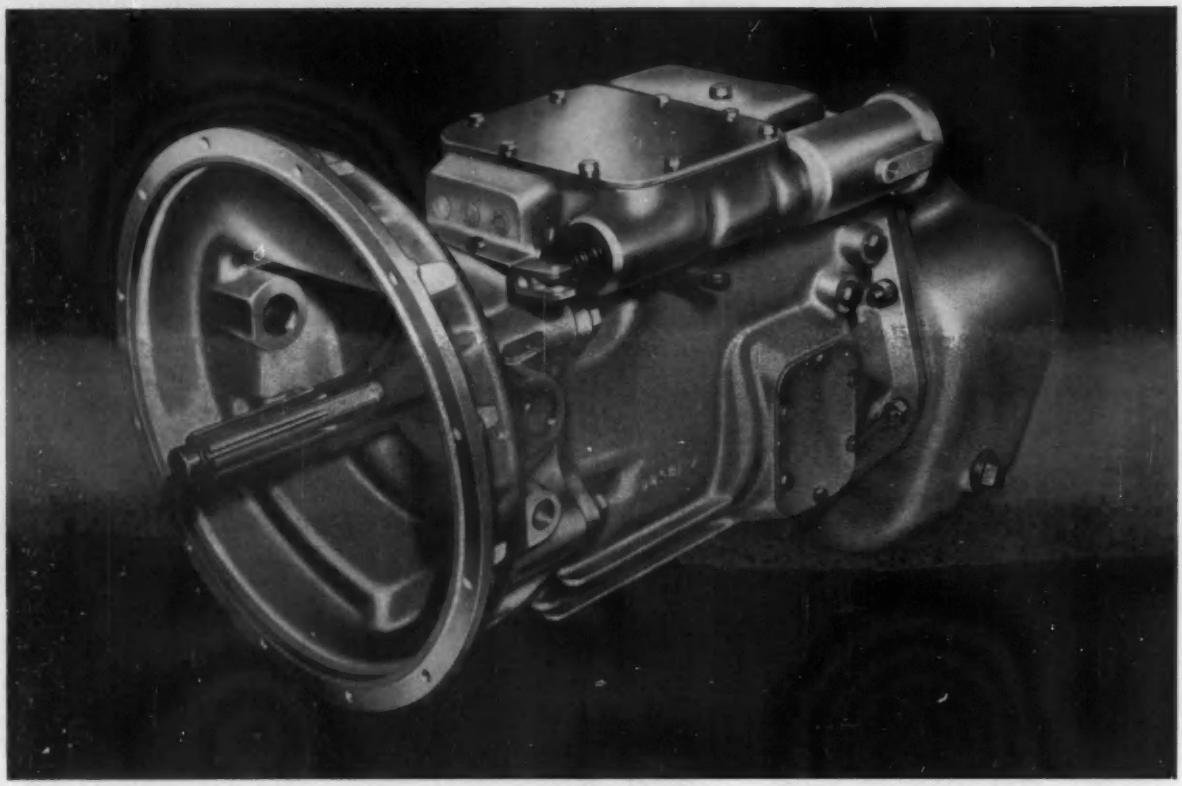
The list of products made with Escon polypropylene is growing every day. Try this versatile molding material for your product. For full information write to Enjay, 15 West 51st Street, New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY



FROM CLARK: A NEW LIGHTWEIGHT 9-SPEED TRANSMISSION

57 years of manufacturing experience...

millions of heavy-duty transmissions...

This is the experience background of Clark's new, lightweight 9-speed transmission . . . a background which gives you:

- ***Light weight.*** **Transmission, complete, *weighs only 515 lbs.* All aluminum housings.**
- **Designed for highway trucks in the *250 to 300 hp range.***
- **9 speeds with ratios matched to the demands of modern diesel hauling. Low-gear ratio, 9.35 to 1, starts heavy loads easily.**
- **Drop-type output shaft, making possible *shorter vehicle wheelbase.***
- ***Power-assist shift* simplifies hookup, cab to transmission . . . greatly reduces shifting effort . . . yet driver retains complete control at all times.**
- **Low silhouette, provides clearance under cab or trailer.**
- **Standard SAE power takeoff openings on both sides.**

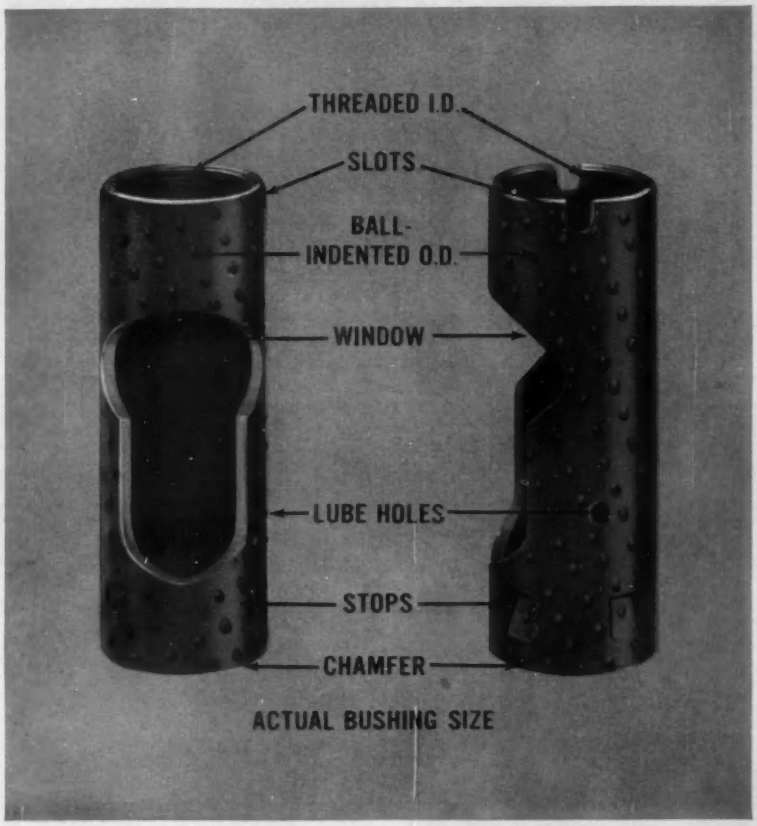
CLARK® EQUIPMENT

For more facts, clip this coupon to your letterhead and mail to

CLARK EQUIPMENT COMPANY

1300 Falahee Road, Jackson 5, Michigan

"EXOTIC" BUSHING MAKES NEW STEERING DESIGN COME TRUE



INSIDE-OUT BUSHING HELPS PUT NEW STEERING MECHANISM INTO PRODUCTION! To perfect a new steering mechanism, an automotive manufacturer required a linkage component. Designers tried making it of machined steel, then plastic . . . both materials failed. But the unusual bushing shown at left, with a number of features F-M engineers helped designers incorporate, solved the problem. It is bronze-on-steel, formed with the ball-indented bronze on the O.D. so the bushing can accommodate sliding motion within the mechanism. A large window makes insertion of a ball socket easy during assembly. Design of the bushing also includes: stops near one end to hold a disc . . . a threaded I.D. on the other with slots for a locking pin . . . holes that supply lubricant to the outer surface. For the F-M customer, all these built-in features helped accomplish this result—easy, efficient assembly and success with a new design.

CAN F-M BUSHINGS SOLVE problems on your board or on your assembly line? Or perhaps a sleeve bearing, thrust washer or spacer? F-M, who makes them all, can provide the answer. F-M engineers, with a wealth of knowledge from years of experience, are available to help design the needed component. This complete technical assistance is one reason why these F-M products are widely specified for use in automobiles, farm equipment, construction machinery and many other products.

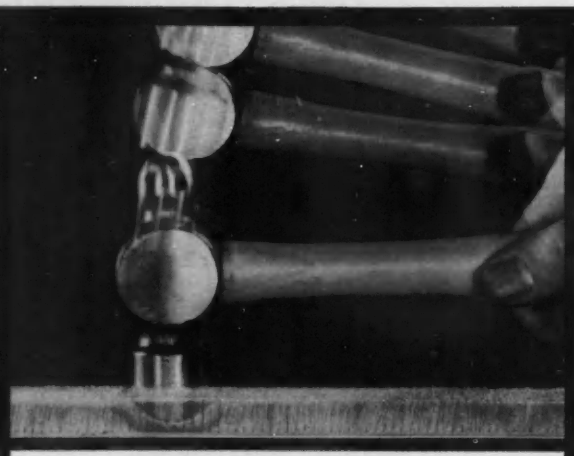
Additional information about bushings is provided in a Design Guide, published by F-M. Helpful literature is also available on sleeve bearings, thrust washers and spacer tubes. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

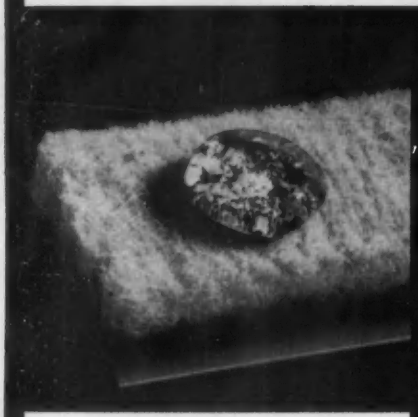
sleeve bearings
bushings spacers
thrust washers

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

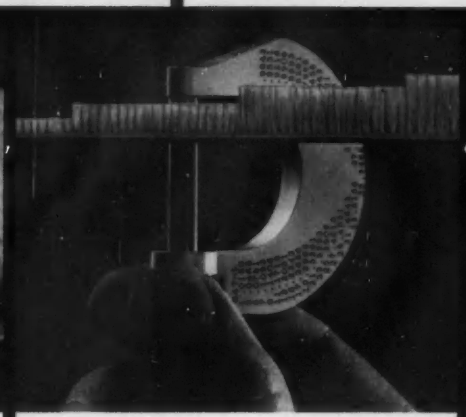
1. DENSITY • Feel the difference in Schlegel woven pile. It's uniformly dense for performance and long life, with density controlled to give proper operation of movable parts and insure a positive seal.



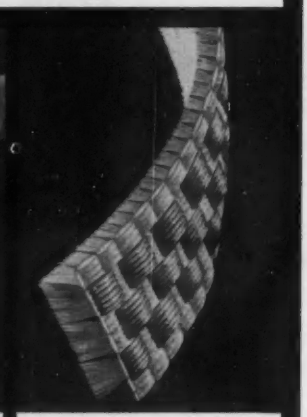
2. RESILIENCE • Schlegel pile withstands the severest shock tests and will not break down or lose its shape. It adjusts quickly to uneven surfaces, keeping an airtight seal under all weather conditions.



3. SILICONE-TREATED • See how Schlegel pile resists moisture? Dow-Corning silicone treatment increases both the moisture resistance and the resilience of the pile.



4. PILE HEIGHT CHOICE • Choose any pile height from .080 to .500. Schlegel holds close tolerances within this range, and offers an assortment of more than 1,000 parts and shapes.



5. INTERWOVEN PILE • Each strand of yarn is wound through and around a strong resin-impregnated backing.

ALL GLASS CHANNEL LINER IS NOT ALIKE!

Five good reasons why **leading engineers specify Schlegel glass run channel liner**

The five product features shown above add up to a glass run channel liner that will last, trouble-free, for as long as the automobile windows you install it in.

Schlegel pile liner in your window channel ensures weather-tight, rattleproof, smooth-operating automobile windows. Schlegel pile won't swell or stick, either—your window will roll up and down effortlessly for years to come.

Test Schlegel pile yourself, in your own wear-testing lab. Then *specify* Schlegel pile liner in your glass run window channels and in other sealing applications. You'll be in good company. Automotive engineers have been specifying Schlegel pile since glass windows were first used in cars.

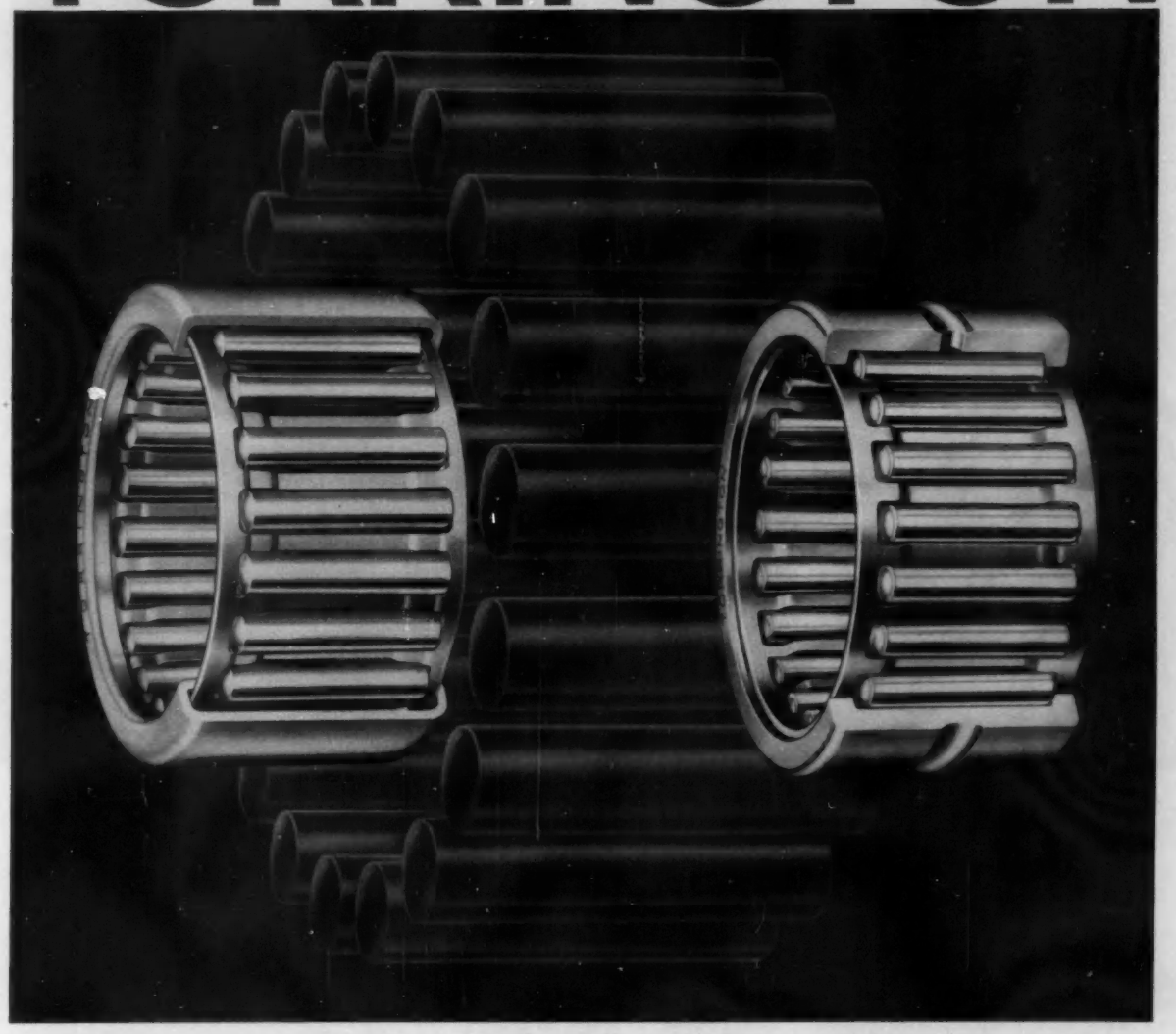
Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N.Y. In Canada, Oakville, Ont.

TORRINGTON



WHATEVER THE DUTY...TORRINGTON HAS A BEARING FOR IT

Take these two bearings:

The unique Torrington Drawn Cup Roller Bearing opens new design possibilities in alternators, power-tool motors, electric mixers, vacuum cleaners and a host of similar products. It is so light, compact and efficient that designers have more flexibility than ever before. Yet the Drawn Cup Roller Bearing costs less than any other anti-friction bearing of comparable performance. In many cases, armature bearing costs have been reduced as much as 50%.

The Torrington Heavy Duty Roller Bearing is ready when the going is tougher. Controlled Contour rollers insure uniform loading and prevent stress concentration at the roller ends. A patented flange-riding retainer insures positive roller guidance and provides ample lubricant storage area. Torrington Heavy Duty Roller Bearings have proved highly successful in two-cycle engines, hydraulic pumps, oil-field equipment and transmission systems.

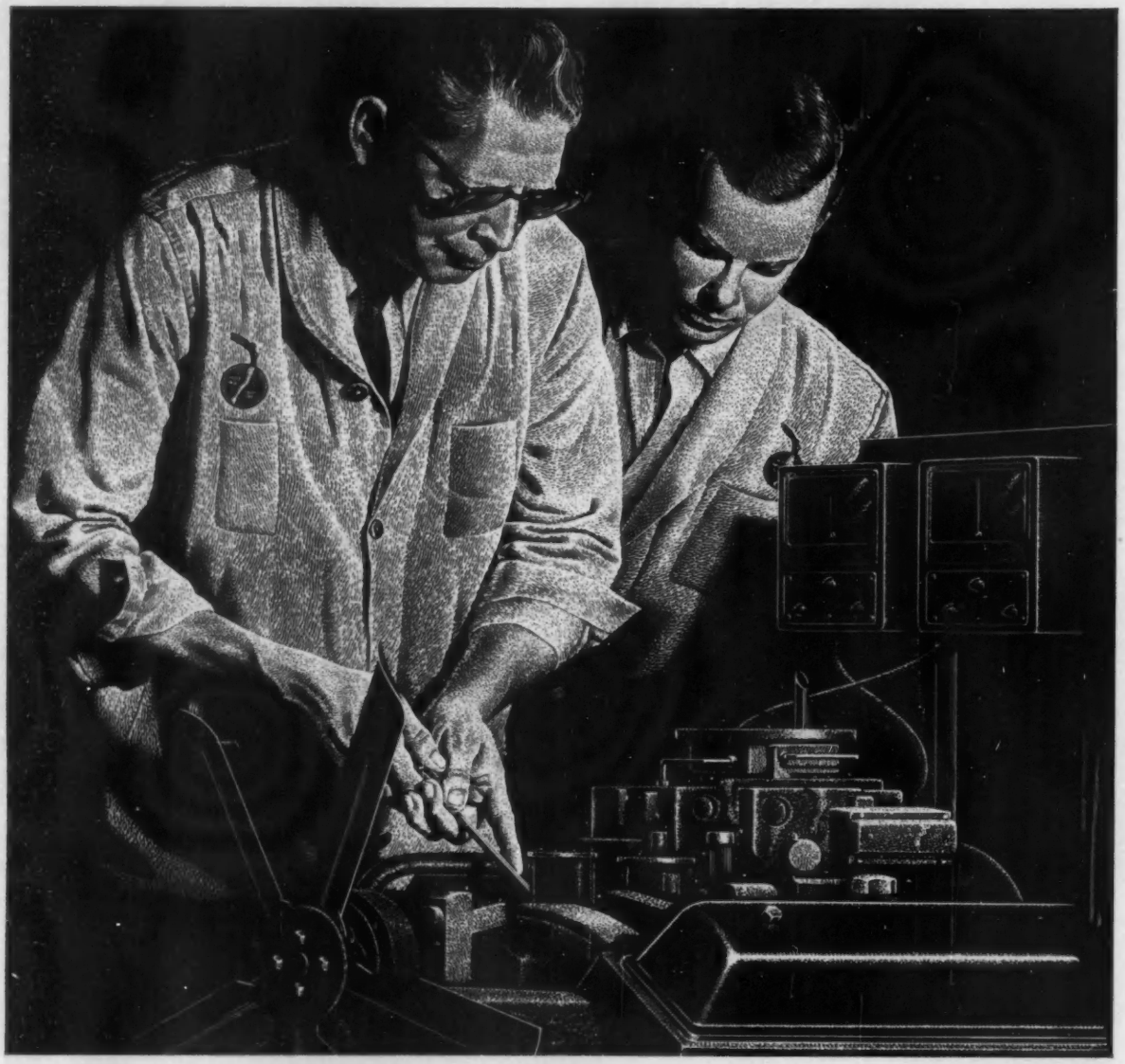
These are just two examples of Torrington's outstanding capability in bearing design and manufacture. Remember that Torrington makes **every** basic type of anti-friction bearing... can supply the bearing that's **exactly** right for your application. Don't hesitate to call us for advice.

progress through precision

TORRINGTON BEARINGS

THE TORRINGTON COMPANY

Torrington, Connecticut • South Bend 21, Indiana



SEALED POWER ... where engineering achievements result from a frame of mind

Modern manufacturing methods, even when they are backed up by rigid quality control, aren't always enough to assure product acceptance—or performance.

At Sealed Power, an intangible (call it a frame of mind, if you wish) goes hand in hand with the unerring ability to develop solutions to piston ring problems.

This frame of mind means that Sealed Power keeps pace with technological advances in engine design. It led also to Sealed Power's technical research center, finest in the piston ring industry.

Most of all, it is reflected in the achievement of Sealed Power engineers and metallurgists who developed the Stainless Steel oil ring, the ring that does its job better than it had ever been done before.

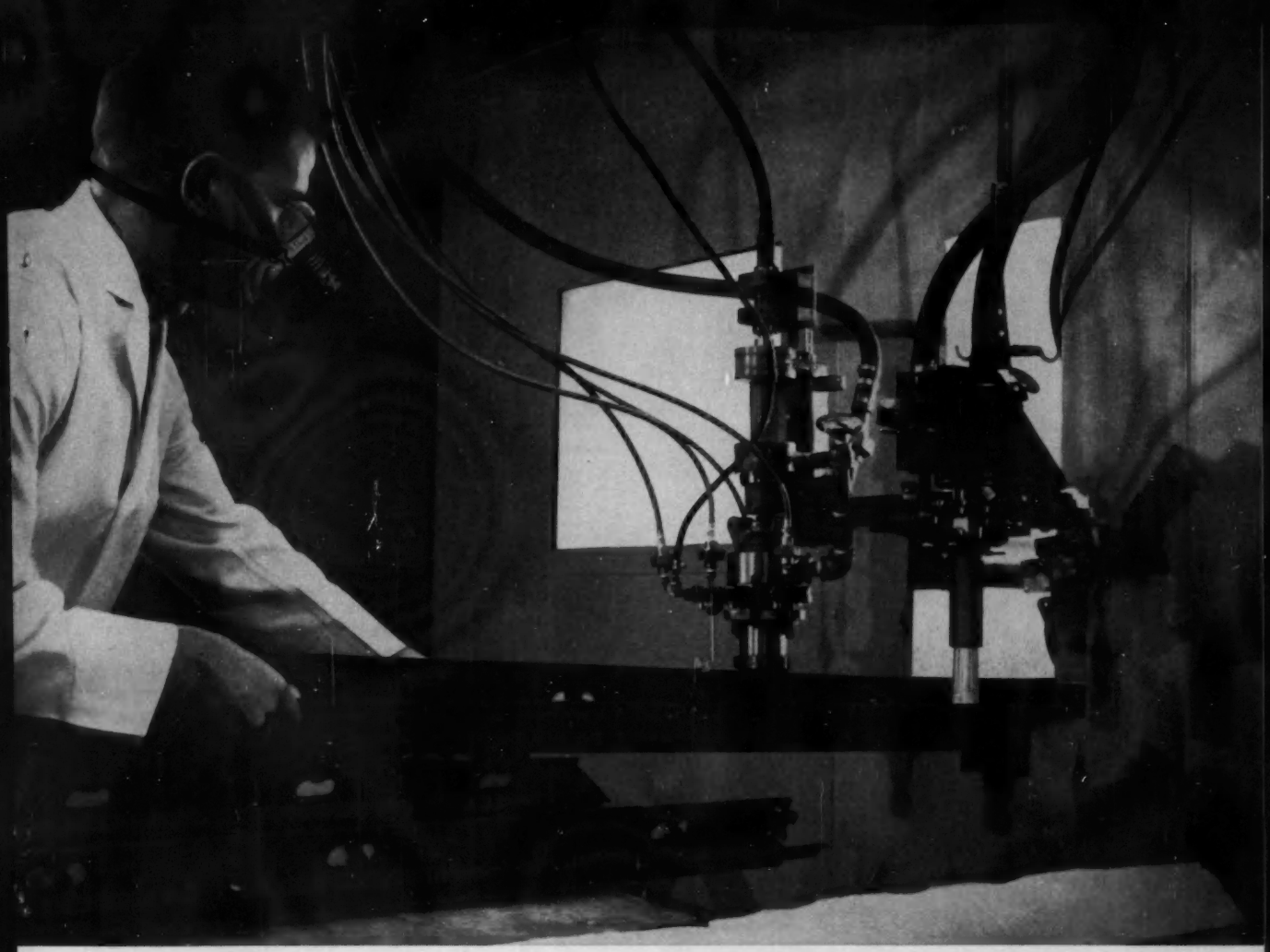
The Sealed Power Stainless Steel oil ring resists pitting and etching, holds its fit, retains tension at operating temperatures. It controls oil, resists sludge, and it cannot rust or corrode. More than 80,000,000 have been factory installed!

Progress through Profits

Sealed Power Preferred Performance

PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • SEALING RINGS FOR ALL APPLICATIONS

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE, 17600 WEST 8 MILE ROAD • PHONE 357-4141



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Voracel is the Dow trademark for the rigid urethane foam resulting from the interaction of Voranol® urethane polyethers and Voranate® isocyanate adducts.

Although new on the automotive scene, Voracel shows excellent results in strengthening sheet metal, especially when it is foamed in place between two sheets. Exceptional ease of application, good adherence to metal, and high resistance to alkali, gasoline, and other common automotive materials indicate its use as lining for hoods and other sheet-metal areas. Voracel can be used to inhibit corrosion in enclosed areas such as rocker panels. For information, call or write to the Dow sales office nearest you.

ENGINE COOLING Ebullient cooling for passenger cars is under intensive research at Dow's Automotive Chemicals Laboratory and seems headed for broad use because of its obvious advantages. The increased efficiency of a vapor system is expected to allow smaller radiators and more freedom of placement—for example, under the floor or in the trunk. This thought is intriguing to designers!

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Created expressly to serve the needs of the automotive industry, Dow's Automotive Chemicals Laboratory is active in technical service and development. This laboratory is continually researching and developing coolants, hydraulic fluids, cutting and grinding fluids, functional fluids, fuel and lubricant additives, and synthetic lubricants. To see how this laboratory can be of assistance to you, contact your nearest Dow sales office or write Chemicals Merchandising in Midland.

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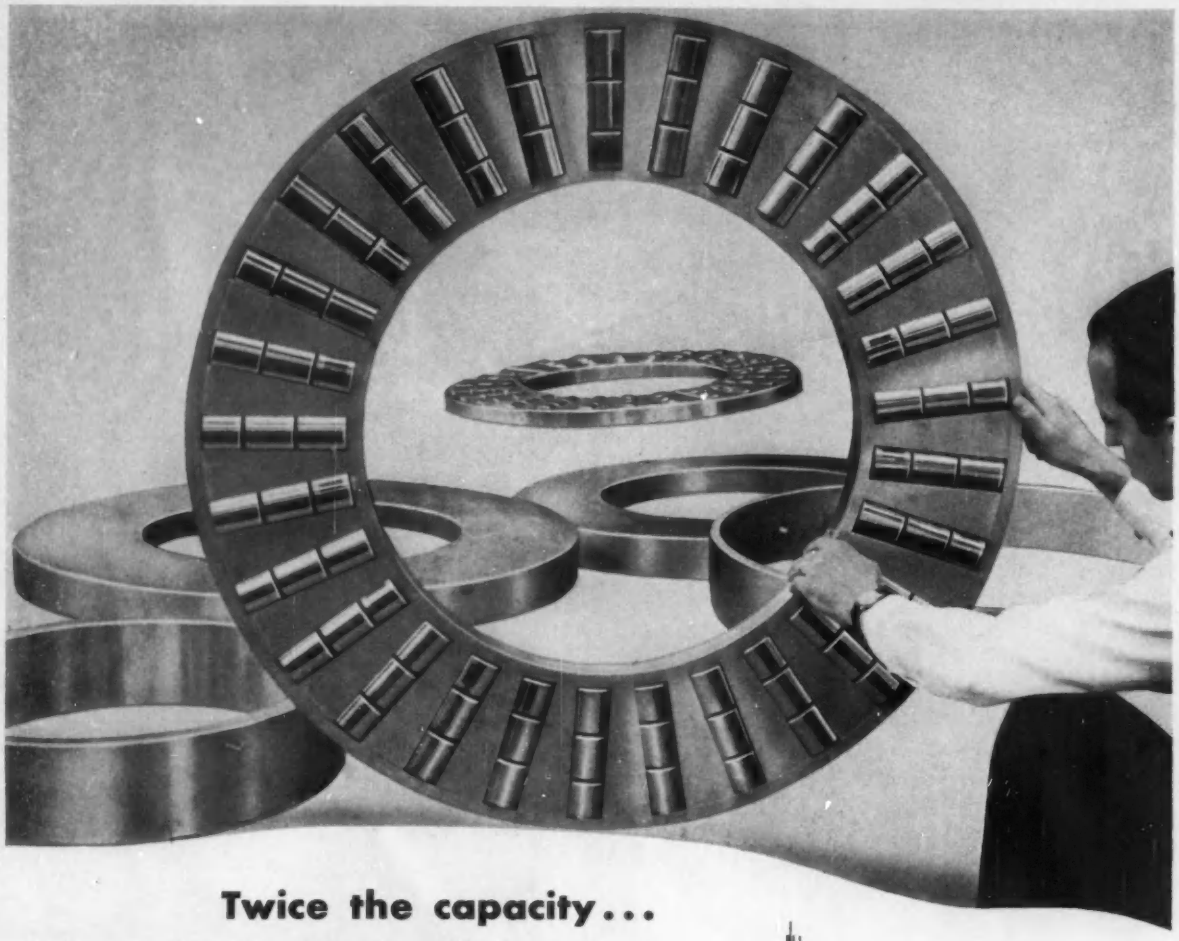

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Arrows indicate path of thrust load in tandem-type bearing.

Drawing at left illustrates *three-stage* design — one of the larger sizes in the Rollway-originated tandem thrust series. It is included in the broad range of Rollway thrust bearings that offers seven *standard* cataloged types . . . plus special-purpose types made to your order.

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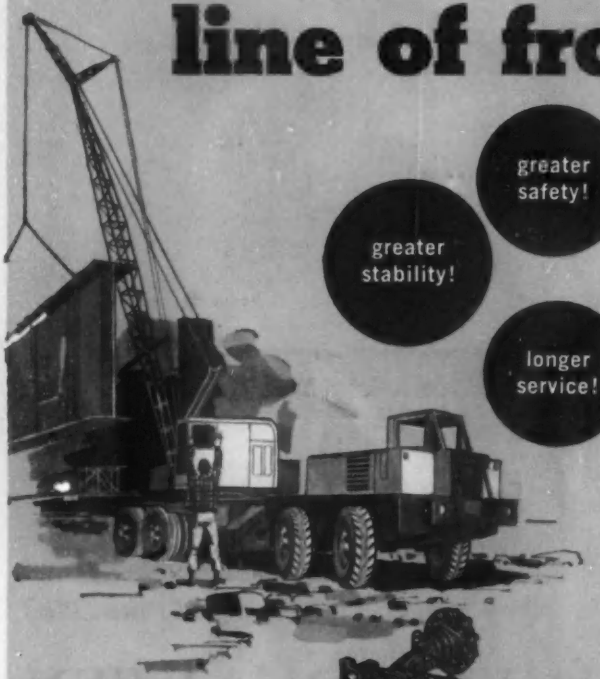

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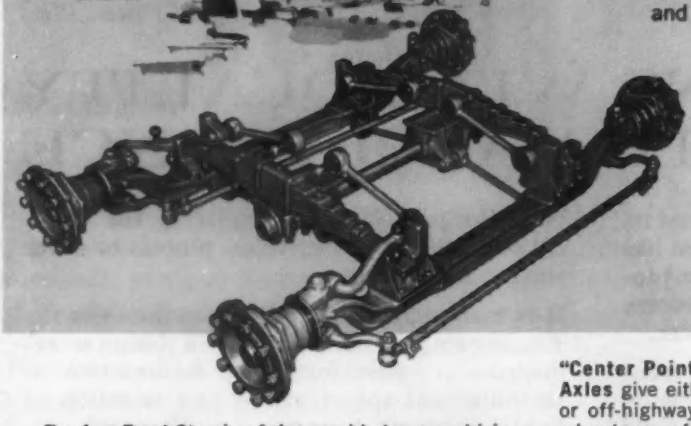

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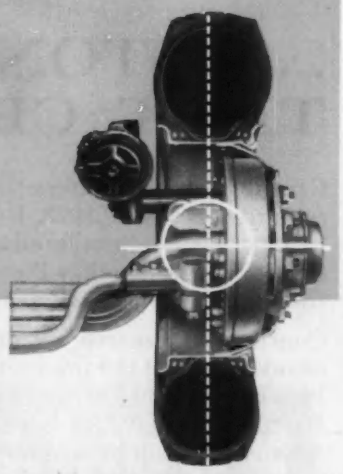

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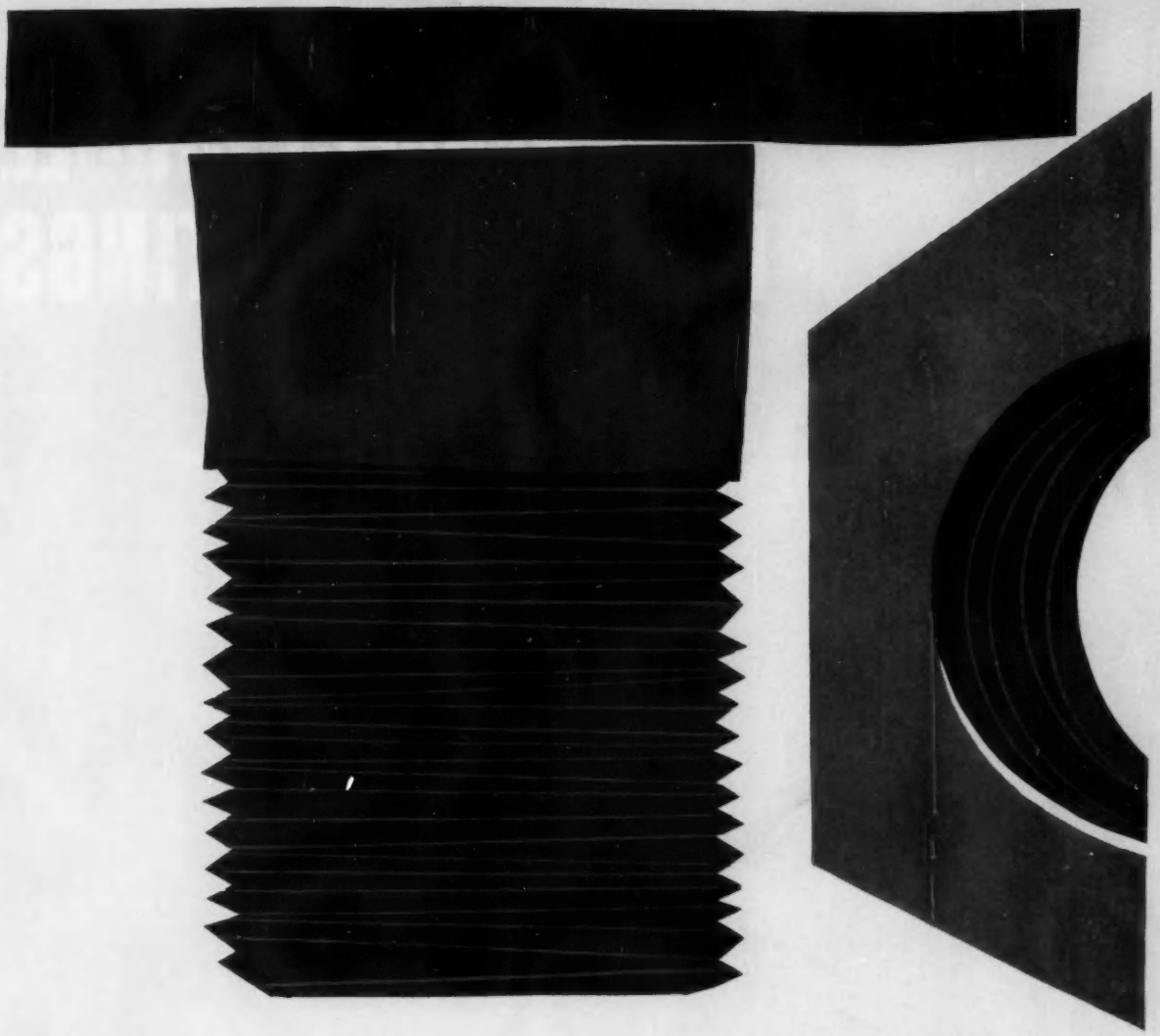

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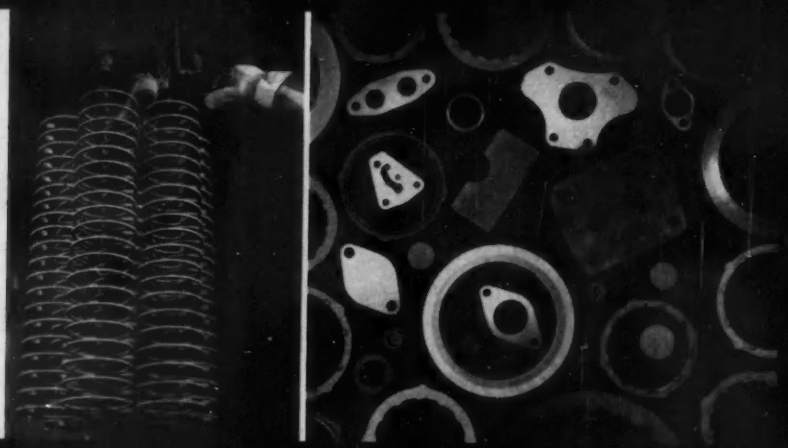

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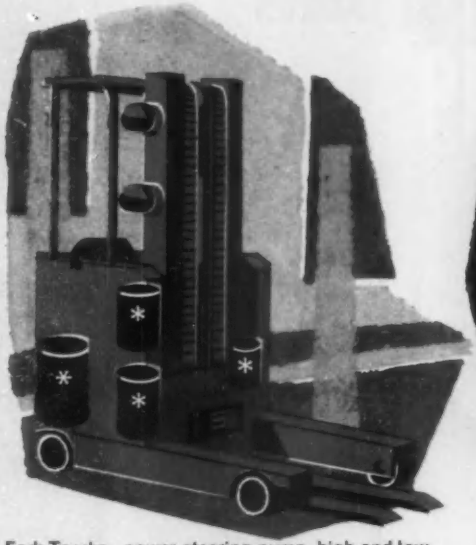

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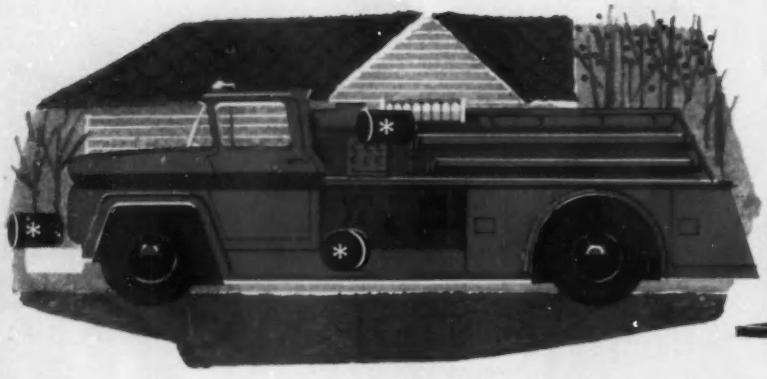
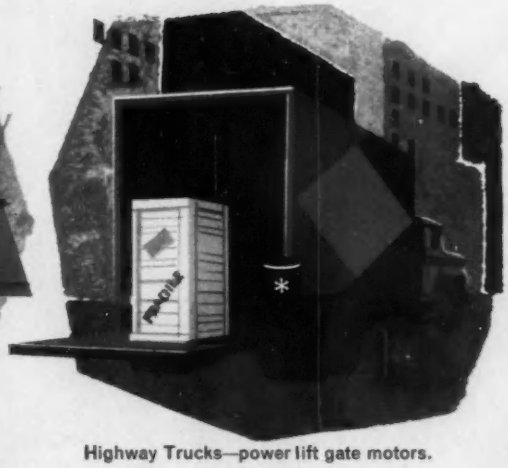


Fire Trucks—siren, hose reel and pump primer motors.



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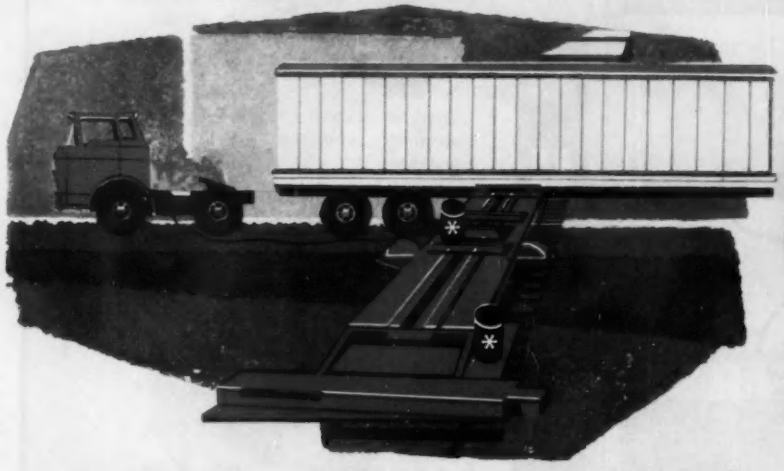

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special needs of power-motion

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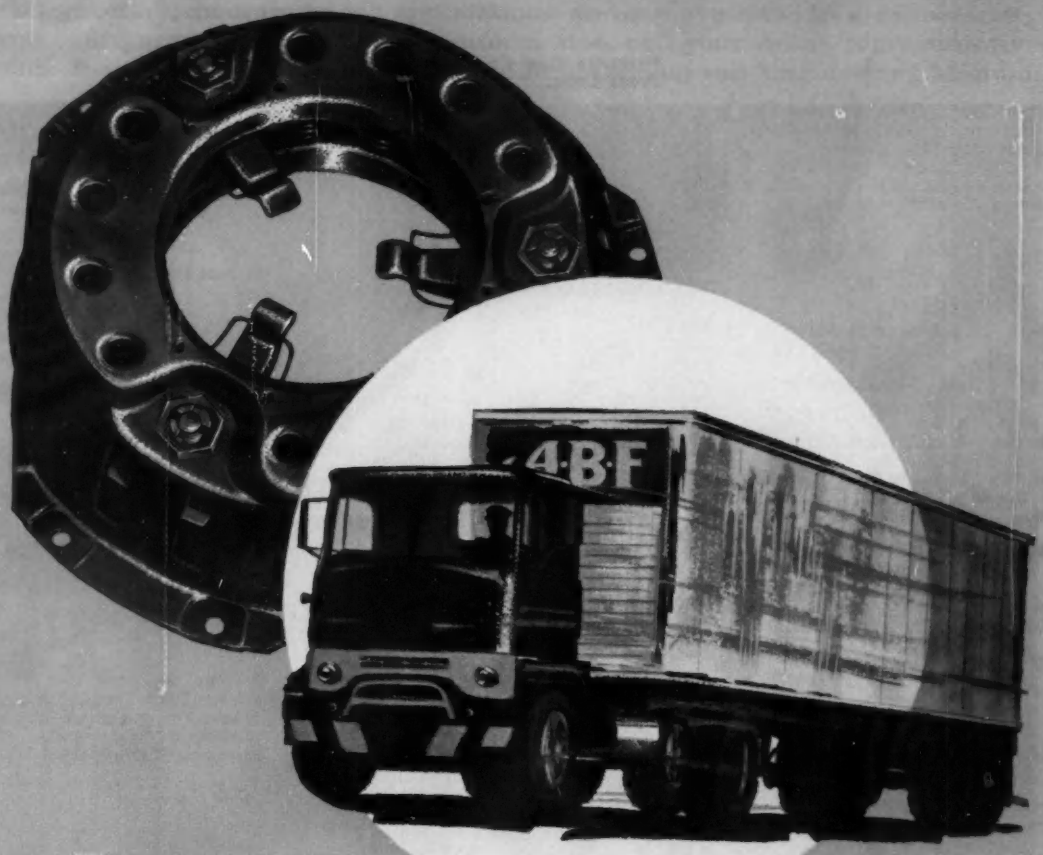

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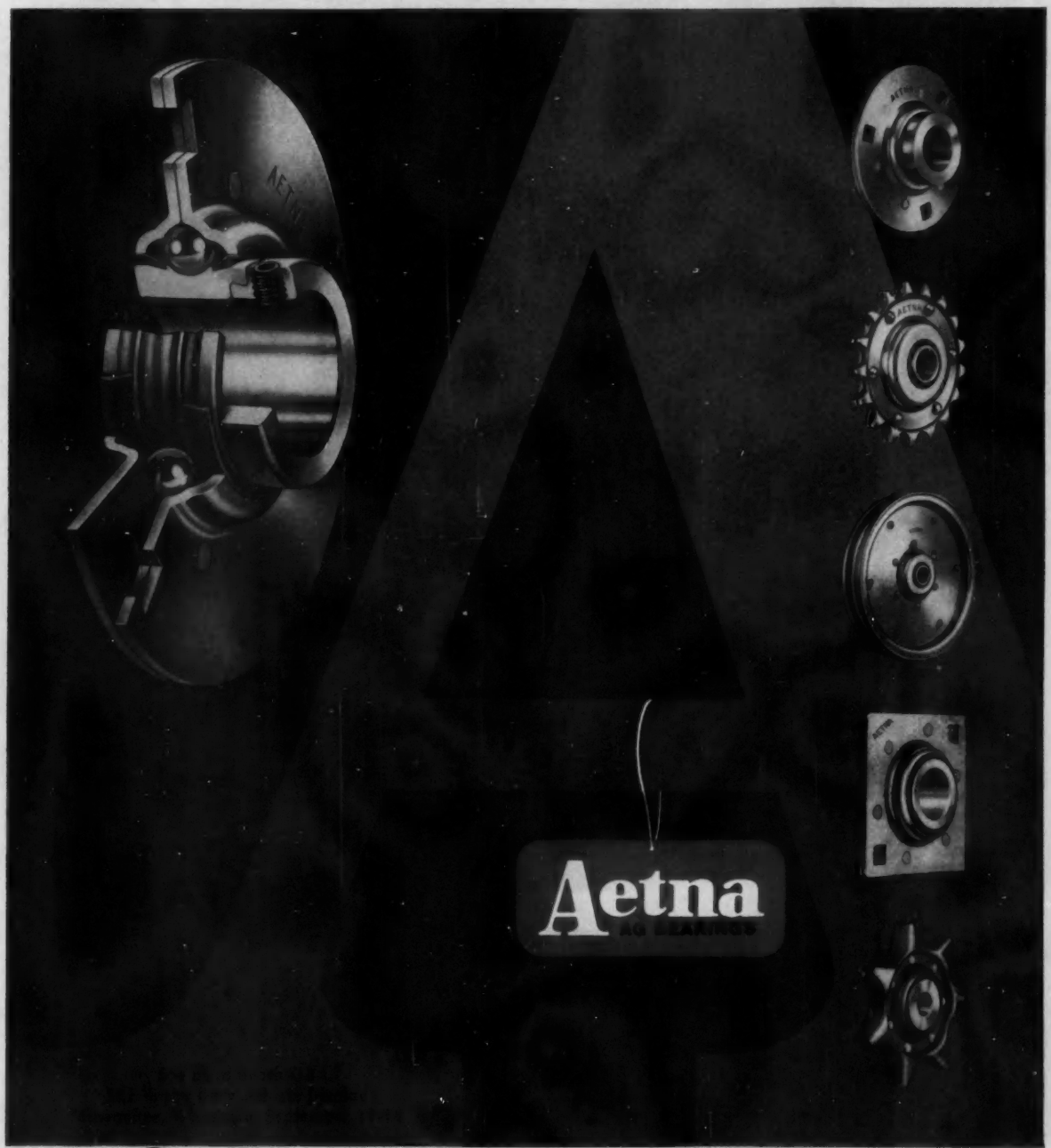

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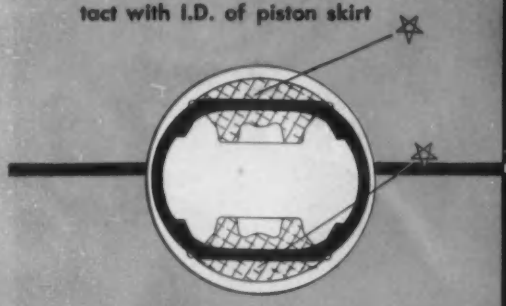

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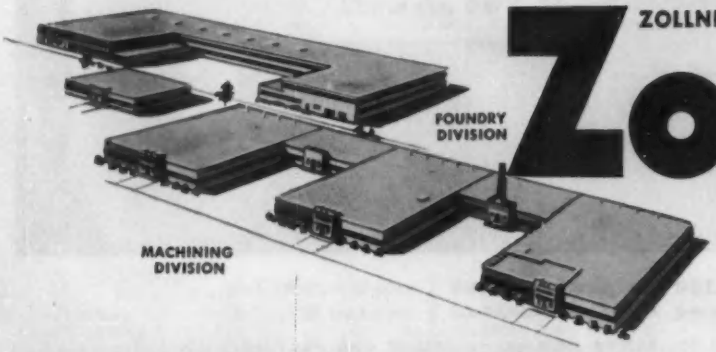

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COMPLETE CO-OPERATION IN ENGINE DEVELOPMENT WITH THE FINEST PISTON FACILITIES

Huber-Warco 10-D Geared for Rugged Roadwork

Three nickel alloy carburizing steels give grader transmission extra strength and toughness

Leveling airfields... maintaining haul-roads... scarifying blacktop. Everyday tasks that test a motor grader's ability to survive shock and stress.

Engineers at H-W anticipated heavy operating loads at the design stage. To give the 10-D grader built-in strength and toughness they specified heat-treated nickel steels for critical transmission gears and shafts.

For the spiral bevel ring gear they selected AISI 4820 steel (3½% nickel). This carburizing steel develops a hard, wear-resisting case backed up by an extremely tough, strong core. Type 4820 is often used for spiral bevel ring gears where operating compressive loads approach 300,000 psi.

For less heavily stressed parts H-W specified AISI 4620 and 4320 carburizing steels (1.8% nickel). Readily heat-treated to a case hardness of 60 Rc min., these steels develop core properties adequate for all but the highest operating stresses. Here is where they are used in the 10-D:

- Transmission gears and shafts
- Final drive parts — bevel pinion, bull pinion, and bull gear

When you design, build or order construction equipment, bring nickel alloy steels in on the planning stage. You'll find materials-engineering data on 11 types of heavy construction equipment in a new, 76-page Inco booklet. For a free copy, request "A-265."

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It's 3-3, top of the ninth in the 6th game of the '35 Series. The Cubs' leadoff man smacks a triple. Detroit fans, sensing disaster, grow quiet. But catcher Mickey Cochrane calls on the best curveball pitcher in the league for his specialty. Many of the pitches Mickey has to dig out of the dirt. But he holds the runner at third and the next three batters go down, two by strikeout, one with a slow roller. In the bottom half, Cochrane scores the winning run. The Tigers are World Champions!

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